A CAHNERS PUBLICATION INTERNATIONAL EDITION MARCH 15, 1990

9 APR 1990

EDN®

Combining cache memory systems with MMUs

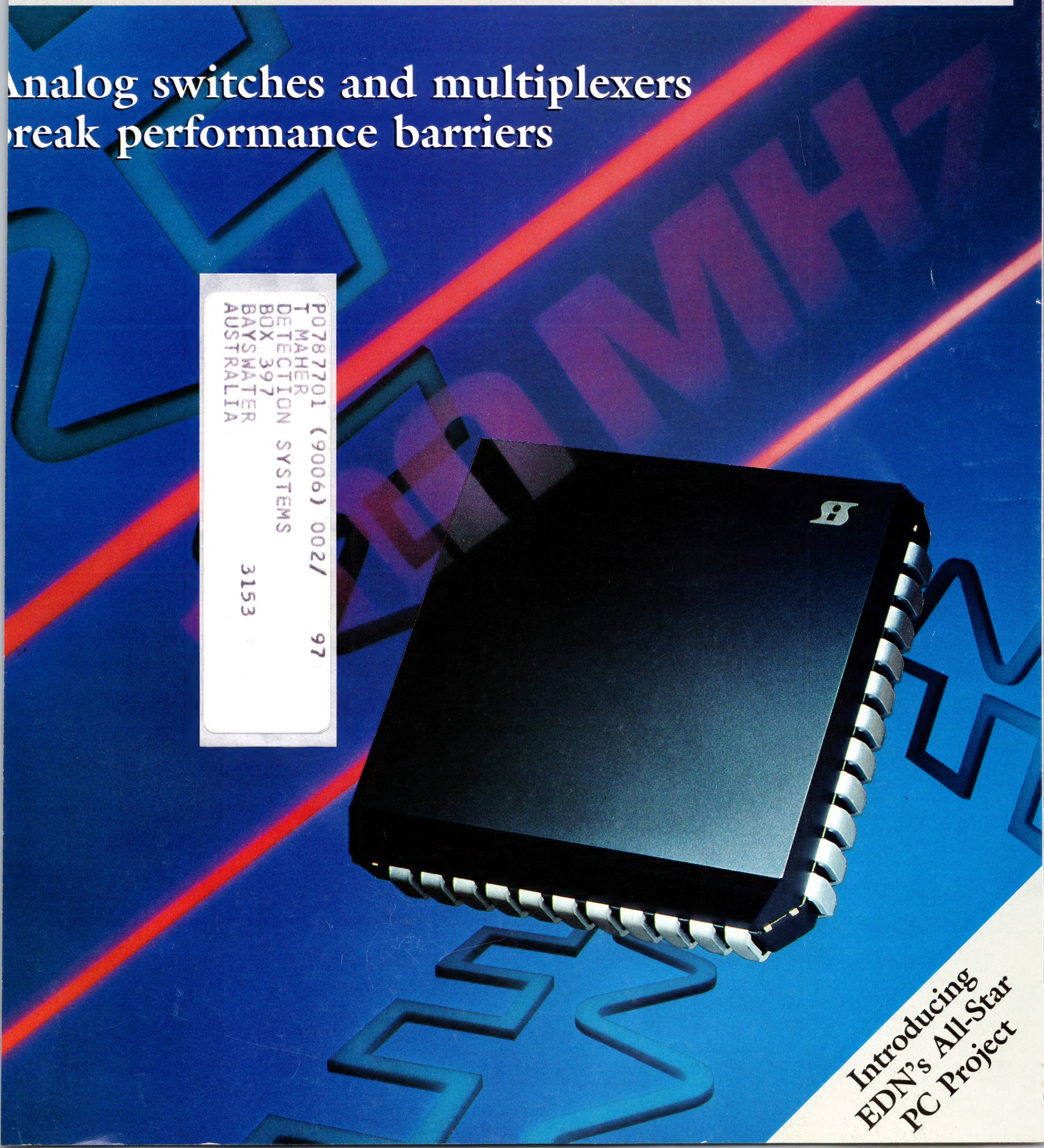
Pulse-modulated dividers

Mathematical software eases problem solving

Stepper motors move loads with speed and precision

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

Analog switches and multiplexers break performance barriers



P0787701 (9006) 002/ 97
T MAHER
DETECTION SYSTEMS
BOX 397
BAYSWATER 3153
AUSTRALIA

Introducing EDN's All-Star PC Project

-

).
ch

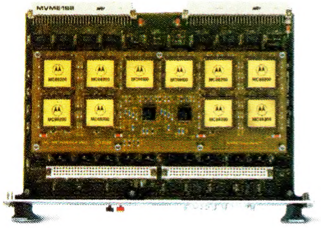
3
ly

31).

l

M

and a full 32-bit VMEbus interface. Performance rated at up to 21 MIPS.



RISC Multiprocessing VMEmodules (MVME188). Family of highly integrated RISC processors and memory, both scalable. Intended for VME system designers with large multi-user and real-time applications. Incorporates HYPERmodules with single, dual or quad processors. Memory scalable from 16 to 64 MB of shared DRAM, tightly coupled to cache through a high-speed memory bus. Performance rated at 17 to 60+ MIPS.

1-
SC

n
le,

memory, up to 98 RS-232C ports, one or two SCSI hard drives, 150 MB streaming tape, in a 6-slot VME enclosure. Performance rated at 17 MIPS.

---

ce

a-
all

rd

enclosure. Performance rated at 17 MIPS.

RISC Multiprocessing Computer System (Delta Series Model 8864). Extremely high-performance multi-user RISC system for high-end database and transaction-oriented applications requiring gigabytes of storage and connecting over 500 users. Incorporates an MVME188 RISC Multiprocessing VMEmodule, with scalable processor and memory features. Includes one to four SCSI hard drives and 150 MB streaming tape in a 20-slot VME enclosure. Performance rated at 17 to 60+ MIPS.

UNIX® and Real-Time Software. Features Motorola's version of UNIX System V, which is compliant with industry standards such as BCS, SVID and POSIX. Extensive RISC software being made available, including programming languages from Ada to Pascal, development tools such as Motorola's VMEexec™ real-time development environment, standard local and wide area networks like TCP/IP, NFS and OSI, and ORACLE and INFORMIX database management systems.

HYPERmodule, Delta Series, VMEexec and Application-Specific Computing are trademarks of Motorola, Inc. UNIX is a registered trademark of AT&T. ORACLE i registered trademark of Oracle Corp. INFORMIX is a registered trademark of Informix Software, Inc.

---

upgrading your product line, new software investments aren't dragging down your bottom line.

To find out about ready-to-wear RISC, call 1-800-556-1234, Ext. 2301; in California, 1-800-441-2345, Ext. 2301. Or write: Motorola Computer Group, 2900 South Diablo Way, DW283, Tempe, AZ 85282. And try us on for size.

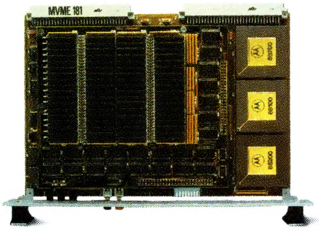
MOTOROLA
Computer Group

CIRCLE NO. 72

X-SMALL.

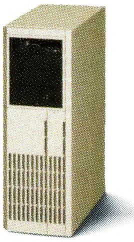
RISC HYPERmodules.™ Alter natives to RISC chip-level designs, with instant scalability from 17 to 60+ MIP Plug-in daughter-cards atta to a motherboard, with one to four MC88100 RISC processors. Integrates up to 12 KB of Cache/MMU for tigh coupled multi-processing.

SMALL.



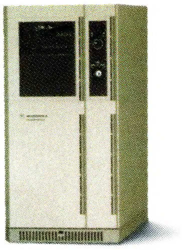
RISC VMEmodule™ *(MVME1* Intended for VME system designers building powerfu RISC-based machines for UNIX or real-time control applications. Integrates an MC88100 RISC processor with two MC88200 Cache/ MMUs, 8 MB of shared DRA

MEDIUM.



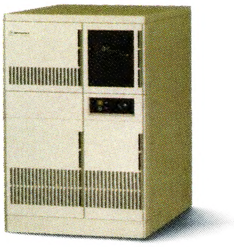
RISC Entry-Level Computer System (Delta Series™ *Model 8408).* Fully integrated hig performance multi-user RI system for technical, commercial and networking applications. Incorporates MVME181 RISC VMEmodu with up to 40 MB of main

LARGE.



RISC Mid-Range Computer System (Delta Series Model 8608). Very high-performan multi-user RISC system for advanced file server and dat base applications. Includes features of the Model 8408, and adds up to four SCSI ha drives, in a 12-slot VME

X-LARGE.



ACCESSORIES

In RISC, one size does not fit all. But one family of products does: Motorola's.

We give you a complete selection of ready-made RISC choices: from microprocessors to VMEmodules to integrated systems—all with standard software and networking capabilities. Plus we can tailor a solution that's just right for your system build through Application-Specific Computing.™

With Motorola, you're protected from future changes in software fashions, too. Our multi-user and real-time 88000 software supports industry-wide compatibility standards, including BCS. That means you have a whole catalog of "shrink-wrapped" software to choose from. So while you're

READY-TO-WEAR
RISC,
FROM MOTOROLA.

STD ROM

A New ROM-based Development Standard from Ziatech

Put Your STD System to Bed

STD ROM streamlines the development of embedded applications. It combines Borland's Turbo Debugger with Ziatech's VIRTUAL TARGET INTERFACE and STD ROM LOCATE to provide an environment for easily "ROMMING" Microsoft C and Turbo C applications.

Single Board Selection

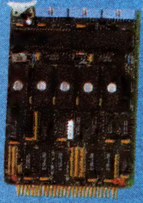
*Ziatech offers the best selection of single board computers in the business. These compact, cost-effective computers are compatible with existing STD Bus products and the new **STD 32** Bus introduced by Ziatech.*

Not Just Another STD Bus Company

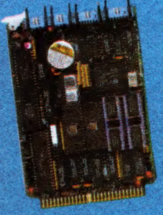
Our on-line technical support, systems engineering courses, guaranteed product availability and superior documentation have made Ziatech the premier STD computer company.

FREE Demo and Data

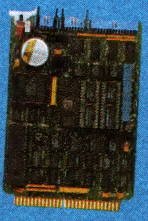
STD ROM can be on your doorstep within days. Call today to arrange a free demonstration. STD ROM and Ziatech are ready to serve your embedded application needs.



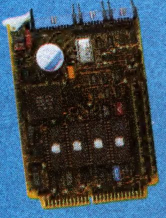
8088



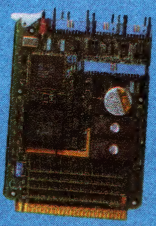
V20



V40



V50



80386SX

ZIATECH
CORPORATION

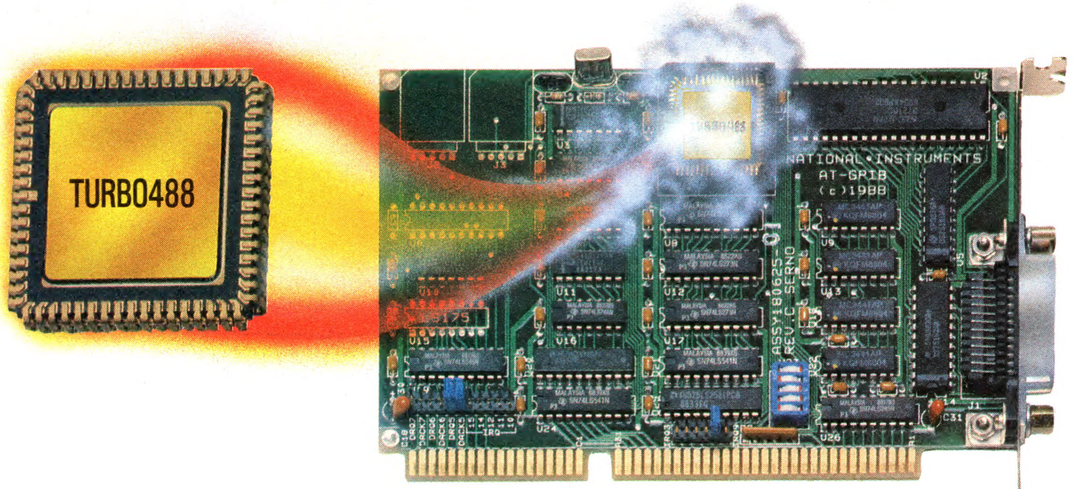
FAX (805) 541-5088
Telephone (805) 541-0488

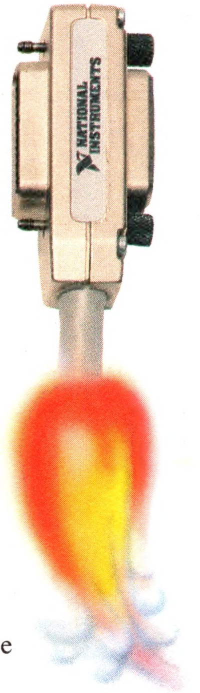
©Copyright 1989 by Ziatech Corporation. All rights reserved.
Product names of other companies may be trademarks of those companies.

Circle No. 100

Maximum IEEE-488 Performance for Your High-Speed AT Computer

Now with
OS/2
Support





The National Instruments AT-GPIB… the new standard for IEEE-488 interfaces

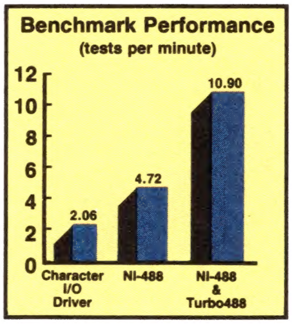
1 Mbytes/sec Transfers – At last, a low-cost IEEE-488 PC/AT controller board can transfer data continuously at the maximum specified rate of 1 Mbytes/sec. The key to this performance is the state-of-the-art FIFO buffering and special last-byte handling circuitry of our custom gate array, Turbo488™. Turbo488 also conserves valuable computer bus bandwidth by packing 8-bit IEEE-488 data bytes into 16-bit words.

Hardware Speed – By moving time consuming software functions into hardware, the Turbo488 significantly reduces the overhead of a software driver too. The combination of the AT-GPIB and our streamlined NI-488 driver gives you the power needed for today's high-speed digitizers.

Industry Standard NI-488 Software – NI-488 has high-level routines that transparently handle IEEE-488 protocol and buffered DMA transfers. These routines can be used with any popular language and are the perfect match for the structured, hierarchical style preferred by users of high-speed, compiled languages such as C and Pascal.

HP-Style Commands, too – NI-488 also gives you the option of using our Universal Language Interface driver to program with Hewlett-Packard-style commands from any DOS language. The speed of this driver is best suited for interpretive languages like BASIC.

A Sound Investment – You can still run your existing NI-488 programs yet automatically take full advantage of the Turbo488. If you're just getting started, our interactive instrument control and menu-driven configuration utilities will get you up and running in no time.



Support – Your relationship with National Instruments does not end when you purchase our products. A staff of applications engineers is always a free phone call away. Demand the best IEEE-488 controller available…give us a call today at **(800) IEEE-488**.

Ask for a *FREE* Catalog

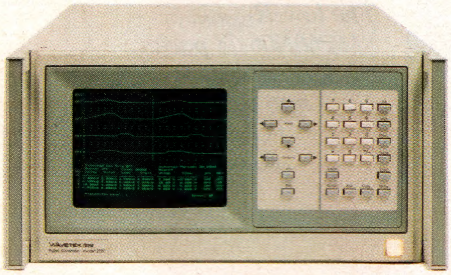
Turbo488 technology is standard on our boards for Micro Channel and Macintosh computers

NATIONAL INSTRUMENTS®
The Software is the Instrument™
6504 Bridge Point Parkway
Austin, Texas 78730
(512) 794-0100
(800) IEEE-488

NIHON NATIONAL INSTRUMENTS K.K. (JAPAN) • (03) 788-1921 • **NATIONAL INSTRUMENTS OF FRANCE** (1) 4865-3370 • **NATIONAL INSTRUMENTS OF ITALY** (2) 4830-1892 • **NATIONAL INSTRUMENTS UNITED KINGDOM** (6) 355-23545 • **ARGENTINA** (1) 46-5776 • **AUSTRALIA** (2) 736-2888 • **AUSTRIA** (316) 391-804 • **BELGIUM** (2) 466-8199 • **CANADA** (416) 890-2010, (613) 596-9300, (514) 747-7878, (403) 295-0822, (604) 988-2195 • **DENMARK** (42) 251-122 • **FINLAND** (358) 0 351-1800 • **GREECE** (1) 361-1283 • **HONG KONG** (2) 0426-2707 • **INDIA** (2) 346-6571, (11) 683-6571 • **INDONESIA** (21) 414-838 • **IRELAND** (3) 846-661414, (3) 427-2282, (44) 236-40840 • **ISRAEL** (3) 324-298 • **KOREA** (2) 776-5340 • **MEXICO** (905) 523-7886 • **THE NETHERLANDS** (7) 099-6360 • **NORWAY** (2) 53-1250 • **PAKISTAN** (42) 879-927 • **PORTUGAL** (1) 545-313 • **SINGAPORE** (65) 336-4713 • **SOUTH AFRICA** (11) 787-0473 • **SPAIN** (1) 555-8112 • **SWEDEN** (8) 792-1100 • **SWITZERLAND** (6) 552-8949 • **TAIWAN/THE REPUBLIC OF CHINA** (2) 703-6280 • **THAILAND** (2) 234-9330 • **VENEZUELA** (2) 959-4036 • **WEST GERMANY** (89) 80-7081

Circle No. 101

Four channels and a choice of edges make our pulse generator a sharp buy.



Why get stuck with a pulse generator that only has two channels…and just one kind of edge? The Wavetek Model 2000 offers both variable and fixed edge modules and up to four channels of output, making it ideal for characterizing or verifying IC performance.

Some channels can have variable edges adjusted to fit the needs of rise-time sensitive devices like ECL and CMOS. Other channels can be pulses with fixed edge speeds of a fraction of a nanosecond—ideal for a clock or the latest high speed circuits, including GaAs.

With a pulse rate of up to 200 MHz and a maximum amplitude of 10V, the Model 2000 is likely to be the only pulse generator you'll need. So you'll save set-up time and training costs. And having four channels in one chassis can eliminate the need to cascade instruments.

Let us show you why the Model 2000 is at the cutting edge of pulse generator technology. We'll even give you a Swiss Army knife just for letting us prove our point.

For a demo, call (619) 279-2200.

WAVETEK®

© 1990 Wavetek Corporation

Circle 104 for Literature

Circle 105 for Demonstration

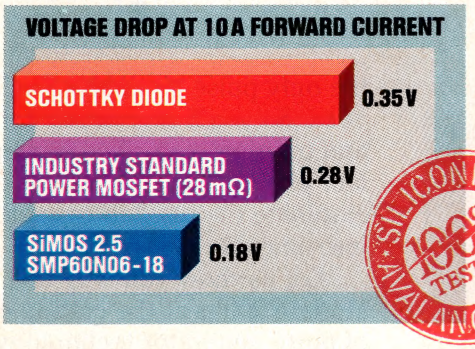
Power density breakthrough for battery-operated systems.

Siliconix' rugged TO-220 SiMOS 2.5 with 36% less $R_{DS(ON)}$ for more efficient power tool & laptop computer designs.

The SiMOS 2.5 power MOSFET has an $R_{DS(ON)}$ of only 18 mΩ, the industry's lowest in a TO-220 package. The result—reduced voltage drop that allows you to create variable-speed power tools featuring more torque and higher speed.

And in laptop computers this means cooler running power supplies and more efficient load management switching.

Now you can use smaller heat sinks to reduce your system's size, weight, and cost. And the low gate charge results in fewer components in your drive circuit.



SILICONIX 100% TESTED AVALANCHE RATED

SiMOS 2.5 for lower voltage drop. The low-$R_{DS(ON)}$ SMP60N06-18 packs 60 V and 60 A into a compact TO-220 package.

Improve efficiency and shrink system size! Ask for our SiMOS 2.5 (SMP60N06-18) Design Kit. Call our toll-free hot line now! **1-800-554-5565, Ext. 9050.**

Siliconix
incorporated

2201 Laurelwood Road, Santa Clara, CA 95054

© 1990 Siliconix inc.

Volume 35, Number 6

EDN® Magazine Edition

March 15, 1990

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

On the cover: *Analog switches and multiplexers that achieve high performance levels can help simplify your circuit design. See the Special Report on pg 130. (Photo courtesy Siliconix Inc)*

SPECIAL REPORT

Analog switches & multiplexers 130

High-performance analog switches and multiplexers save pc-board space and give you more options when switching high-voltage and wideband signals.—*Doug Conner, Regional Editor*

EDN's All-Star PC Project—Part 1 142

INNOVATION™ *Driving Electronic Technology Into The Next Century*

It seemed so easy. Build the World's Most Powerful PC by picking the best components and melding them into an integrated whole. But every integration is tough, and the All-Star PC takes the problems of system integration to the extreme. Part 1 tells you why we undertook this project and lays the foundation for the other four parts.—*Steven H Leibson, Senior Regional Editor*

DESIGN FEATURES

Pulse-modulated divider suits multichannel systems 159

There are a handful of schemes for implementing analog division, and the traditional circuits perform quite well for many applications. However, a somewhat neglected circuit—the pulse-modulated divider—provides superior gain-matching characteristics for multichannel systems.—*Dan Harres, McDonnell Douglas Electronic Systems Co*

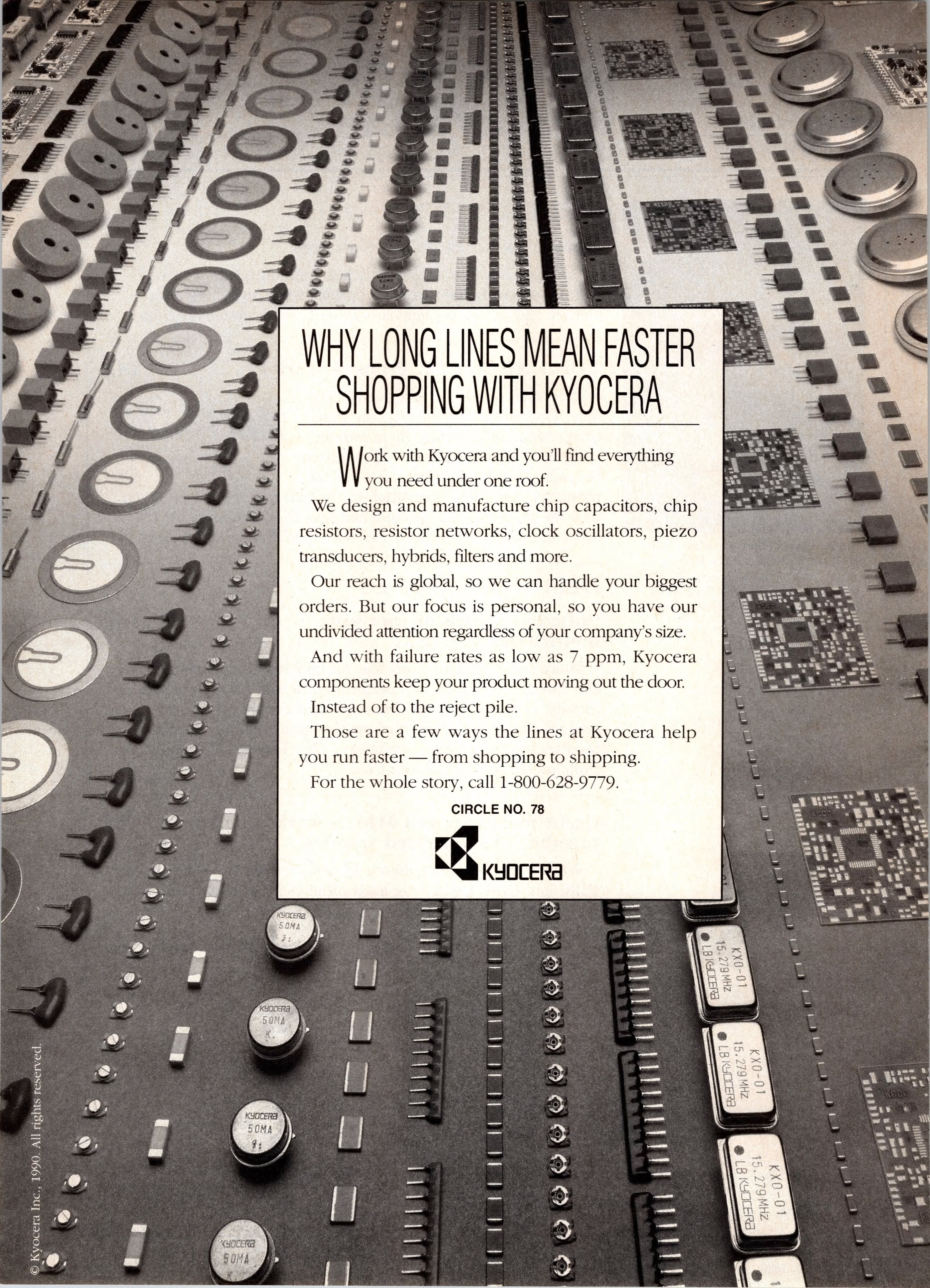
Cache memories and MMUs work together in high-speed systems 169

When you use cache-memory systems with today's high-speed RISC and CISC CPUs, you must often coordinate them with sophisticated memory-management units.—*Raymond M Leong, Cypress Semiconductor*

Continued on page 7

EDN®(ISSN 0012-7515) is published 49 times a year (biweekly with 2 additional issues a month, except for February, which has 3 additional issues and July and December which have 1 additional issue) by Cahners Publishing Company, A Division of Reed Publishing USA, 275 Washington Street, Newton, MA 02158-1630. Terrence M McDermott, President; Frank Sibley, Senior Vice President/General Manager, Boston Division; Jerry D Neth, Senior Vice President/Publishing Operations; J J Walsh, Senior Vice President/Finance; Thomas J Dellamaria, Senior Vice President/Production and Manufacturing; Ralph Knupp, Vice President/Human Resources. Circulation records are maintained at Cahners Publishing Company, 44 Cook Street, Denver, CO 80206-5800. Telephone: (303) 388-4511. Second-class postage paid at Denver, CO 80206-5800 and additional mailing offices. POSTMASTER: Send address corrections to EDN® at the Denver address. EDN® copyright 1989 by Reed Publishing USA; Ronald G Segel, Chairman and Chief Executive Officer; Robert L Krakoff, President and Chief Operating Officer; William M Platt, Senior Vice President. Annual subscription rates for nonqualified people: USA, $105/year; Canada/Mexico, $125/year; Europe air mail, $150/year; all other nations, $150/year for surface mail and $230/year for air mail. Single copies are available for $10. Please address all subscription mail to Eric Schmierer, 44 Cook Street, Denver, CO 80206-5800.

BPA ABP



WHY LONG LINES MEAN FASTER SHOPPING WITH KYOCERA

Work with Kyocera and you'll find everything you need under one roof.

We design and manufacture chip capacitors, chip resistors, resistor networks, clock oscillators, piezo transducers, hybrids, filters and more.

Our reach is global, so we can handle your biggest orders. But our focus is personal, so you have our undivided attention regardless of your company's size.

And with failure rates as low as 7 ppm, Kyocera components keep your product moving out the door.

Instead of to the reject pile.

Those are a few ways the lines at Kyocera help you run faster — from shopping to shipping.

For the whole story, call 1-800-628-9779.

CIRCLE NO. 78

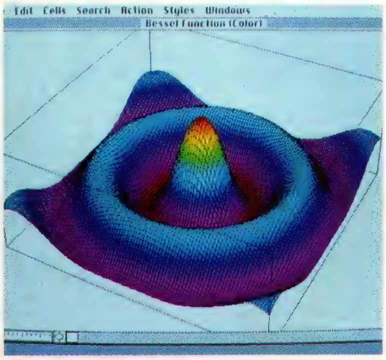
KYOCERA

© Kyocera Inc., 1990. All rights reserved.

Continued from page 5

EDN Magazine Edition®

March 15, 1990



***Let the mathematical software do the number crunching** so you can do the problem solving (pg 53).*

TECHNOLOGY UPDATES

Mathematical software packages: Taking the drudgery out of problem solving — 53

General-purpose mathematical applications packages for IBM PC-compatible and Apple Macintosh computers fill an unusual place in the technical software market. Although several of the products include their own programming languages, these packages are primarily for people who have complex problems to solve but who don't want to become programmers.—*Dan Strassberg, Associate Editor*

Stepper motors: Devices handle strict positioning needs — 83

Stepper motors can control shaft speed and position without extra feedback sensors and associated electronics, making them a good choice for applications in which low cost and simple motion control are paramount. Furthermore, steppers are generally very accurate and reliable: Almost every kind of printer, plotter, and chart recorder uses these motors.—*Tom Ormond, Senior Editor*

Microcontroller development systems: Advances simplify μC design tasks — 101

The prices of 8-bit microcontrollers are plunging, but the cost of development systems for these devices range from a few hundred dollars to over a hundred thousand dollars. For most μC development tasks, the most effecient and cost-effective tools come in an assortment of hardware and software products that sell for \$1000 to \$10,000.—*J D Mosley, Regional Editor*

EDITOR'S CHOICE

Handheld scientific calculator 121

PRODUCT UPDATES

High-resolution workstations 122
Continuous-time filter IC 124
PC-board router 126

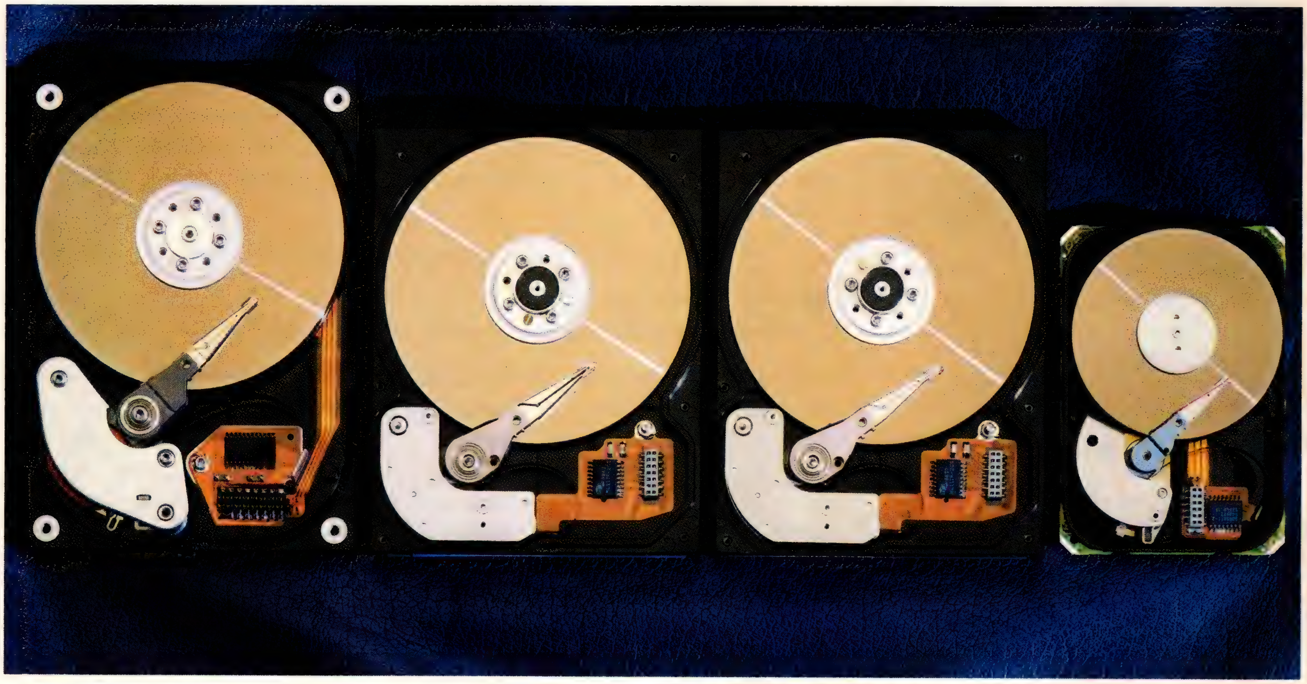
Continued on page 9

EDN magazine now offers Express Request, a convenient way to retrieve product information by phone. See the Reader Service Card in the front for details on how to use this free service.

Express Request

Cahners Publishing Company, A Division of Reed Publishing USA ☐ Specialized Business Magazines for Building & Construction ☐ Manufacturing ☐ Foodservice & Lodging ☐ Electronics & Computers ☐ Interior Design ☐ Printing ☐ Publishing ☐ Industrial Research & Technology ☐ Health Care ☐ and Entertainment. Specialized Consumer Magazines: ☐ American Baby ☐ and Modern Bride.

WE'VE DECIDED TO CHANGE THE RULES. AGAIN.



In just three short years, Conner Peripherals has earned a unique reputation as a company that responds to its customers with speed and innovation. With products that don't just follow the standards, but set them.

Today, Conner is prepared to deliver its third wave of innovative disk drives to its customers. Drives that, once again, change the rules.

Kato Series. Conner presents the first drive of the third wave. Our first pocket-sized disk drive, the 2.5-inch Kato represents a new standard for the emerging notebook PC market. Providing 20MB of low power storage in an ultra-small, ultra-light, completely portable package.

Stubby Series. These entirely new 20 and 40MB *quarter-height* drives let designers pack their new laptop and notebook designs with desktop performance inside a reduced space. All, while operating at a cool 1.5 watts.

Hopi Series. In its 120MB configuration, Hopi becomes the industry's highest capacity 1-inch height drive. And the new standard for upgrading the storage capacity of today's premium laptop designs.

Lighter. Faster. Cooler. Thinner. Shorter. Conner has helped its customers to change the rules. Again.

CONNER

THE THIRD WAVE

World Headquarters: 3081 Zanker Road, San Jose, CA 95134. Telephone: 408/433-3340 Fax: 408/433-3303 **Sales Offices:** Boston: 508/660-1088 • Dallas: 214/680-2913 Los Angeles: 714/455-2777 • San Jose: 408/433-3340 • Singapore: 65/2845366 • Taipei: 886/2775-4352 • Tokyo: 81/3-597-8321 • Munich: 49/89-811-2097 • London: 44/249-659-930

CIRCLE NO. 75

Continued from page 7

EDN Magazine Edition®

March 15, 1990

VP/Publisher
Peter D Coley
VP/Editor/Editorial Director
Jonathan Titus
Managing Editor
Joan Morrow
Assistant Managing Editor
Susan L Rastellini
Special Projects
Gary Legg
Home Office Editorial Staff
275 Washington St, Newton, MA 02158
(617) 964-3030
Tom Ormond, *Senior Editor*
Charles Small, *Senior Editor*
Jay Fraser, *Associate Editor*
John A Gallant, *Associate Editor*
Michael C Markowitz, *Associate Editor*
Dave Pryce, *Associate Editor*
James P Scanlan, *Associate Editor*
Julie Anne Schofield, *Associate Editor*
Dan Strassberg, *Associate Editor*
Anne Watson Swager, *Associate Editor*
Chris Terry, *Associate Editor*
Kathleen M Vejvoda, *Associate Editor*
Helen McElwee, *Senior Copy Editor*
Susan Bureau, *Copy Editor*
Christine McElvenny, *Senior Production Editor*
Gabriella A Fodor, *Production Editor*
Brian J Tobey, *Production Editor*
Editorial Field Offices
Steven H Leibson, *Senior Regional Editor*
Boulder, CO: (303) 494-2233
Doug Conner, *Regional Editor*
Atascadero, CA: (805) 461-9669
J D Mosley, *Regional Editor*
Arlington, TX: (817) 465-4961
Richard A Quinnell, *Regional Editor*
Aptos, CA: (408) 685-8028
Maury Wright, *Regional Editor*
San Diego, CA: (619) 748-6785
Brian Kerridge, *European Editor*
(603) 630782
(St Francis House, Queens Rd,
Norwich, NR1 3PN, UK)
Contributing Editors
Robert Pease, Don Powers,
Bill Travis
Editorial Coordinator
Kathy Leonard
Editorial Services
Helen Benedict, Nicky Woodlock
Art Staff
Ken Racicot, *Senior Art Director*
Chinsoo Chung, *Associate Art Director*
Cathy Madigan, *Staff Artist*
Production/Manufacturing Staff
Andrew A Jantz, *Production Supervisor*
Deborah Hodin, *Production Assistant*
Lisa K Mariano, *Production Assistant*
Michele R Weinberg, *Production Assistant*
Diane Malone, *Composition*
Director of Art Department
Joan Kelly
Norman Graf, *Associate*
VP/Production/Manufacturing
Wayne Hulitzky
Director of Production/Manufacturing
John R Sanders
Business Director
Deborah Virtue
Marketing Communications
Anne Foley, *Promotion Manager*
Sara Morris, *Marketing Services Administrator*

DESIGN IDEAS

Power controller switches cycles 179
Spice models 3-terminal reference 180
Dual-port RAM doubles bit width 181
F/V converter has variable slope 182
RS-232C ports survive insults 184

EDITORIAL 49

Recent studies have linked extremely low-frequency electric fields to cancer. It's time to examine our standards for exposure to electromagnetic radiation in this portion of the spectrum.

NEW PRODUCTS

CAE & Software Development Tools 189
Integrated Circuits 192
Test & Measurement Instruments 196
Components & Power Supplies 199
Computers & Peripherals 204

PROFESSIONAL ISSUES 233

John Holland and his robots—*Jay Fraser, Associate Editor*

DEPARTMENTS

News Breaks 21
Signals & Noise 28
Calendar 40
Literature 209
Career Opportunities 238
Business/Corporate Staff 243
EDN's International Advertisers Index 244

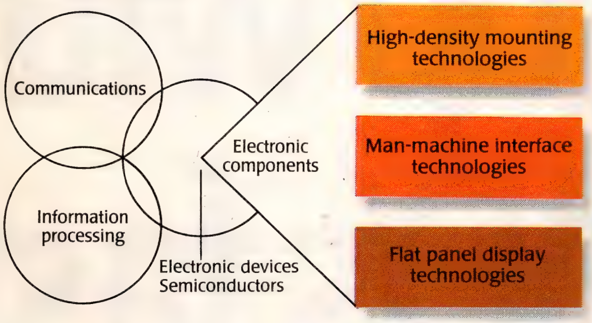
Before we could make it big...

...we had to make it small.

Every oak starts with a tiny acorn. And every computer or communications system starts with thousands of component parts.

For over half a century, Fujitsu has specialized in computers and communications. And we've grown into the world's third largest computer company and the tenth largest maker of communications systems.

One reason for our success is the quality of our component parts. A great many of them made by Fujitsu.


Communications
Information processing
Electronic components
Electronic devices Semiconductors
High-density mounting technologies
Man-machine interface technologies
Flat panel display technologies

We've developed the specialized component and electronic device technology required for advanced computer and communications systems. Half-pitch connectors and miniature relays for high density mounting. Large-screen plasma and liquid crystal displays. Ergonomically designed keyboards and low-noise, high-speed thermal printers for advanced man-machine interface devices. And more.

We've also developed the systems concepts and experience to see that our computer and communications components technology is always state-of-the-art.

Yours can be, too.

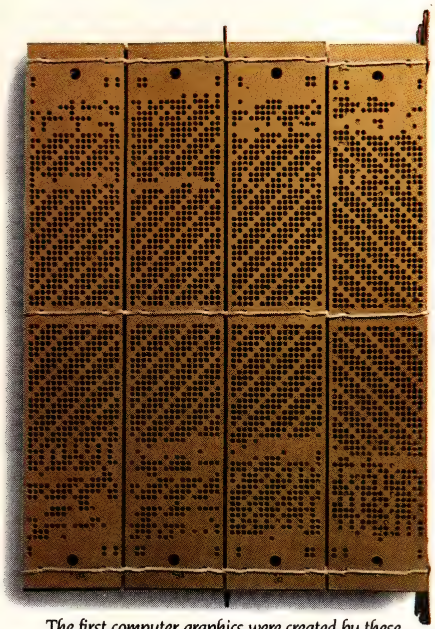
Whether you're a big oak – or a little acorn – we have the specialized components technology and computer and communications application experience to help your business grow.

To find out what our experience in electronic devices and components for computer and communications systems can do for you, call Fujitsu today.

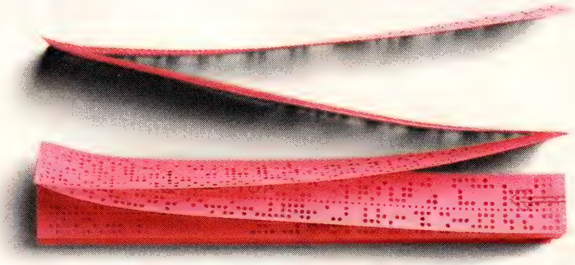
FUJITSU

FUJITSU MIKROELEKTRONIK GmbH: Lyoner Straße 44-48, Arabella Center 9. OG./A, D-6000 Frankfurt Niederrad 71, F.R. Germany Phone: 069-66320 Telex: 0411963 Fax: 069-6632122
FUJITSU COMPONENT OF AMERICA, INC.: 3330 Scott Blvd., Santa Clara, California 95054-3197, U.S.A. Phone: 408-562-1000 Telex: 910-338-0190 Fax: 408-727-0355
FUJITSU MICROELECTRONICS ASIA PTE LIMITED: #06-04 to #06-07, Plaza By The Park, No. 51 Bras Basah Road, Singapore 0719 Phone: 336-1600 Telex: 55573 Fax: 336-1609
FUJITSU LIMITED (Electronic Components, Electronic Devices International Technical Marketing Div.): Furukawa Sogo Bldg., 6-1, Marunouchi 2-chome, Chiyoda-ku, Tokyo 100, Japan
Phone: National (03) 216-3211 International (Int'l Prefix) 81-3-216-3211 Telex: 2224361 Fax: (03) 215-1961

CIRCLE NO. 77



The first computer graphics were created by these cards designed for use on the Jacquard loom in the late 18th Century.



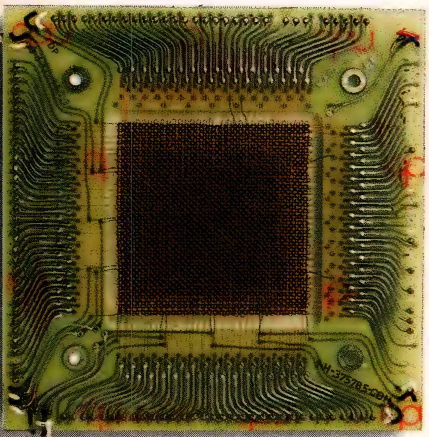
Each 2.5 x 21.5 cm section has a whopping 1360 possible digits. Users of paper tape were probably the first to pray for a paperless office.

The Selectron tube had random access to 256 bits of storage with a cycle time of a mere 20ms.

Keep up with
with AMD's fast

Special thanks to The Computer Museum, Boston. © 1989 Advanced Micro Devices, Inc. Product or company mentioned herein may be trademarks and/or registered trademarks of their respective companies.

Bruxelles (02-2) 771 91 42 • Geneva (02) 2880025 • Hanover area (0511) 73 60 85 • Hong Kong (5) 8654525 • London area (0483) 740440 • Manchester area (0925) 828008 • Milano (02) 3533241 • München (089) 41 14-0 • Osaka (06) 243-3250 • Paris (1) 49 75 10 10 • Seoul (02) 784-7598 • Singapore (65) 348 1188 • Stockholm (08) 733 03 50 • Stuttgart (0711) 62 33 77 • Taiwan (02) 7213393 • Tokyo (03) 345-8241 • Latin America, Fort Lauderdale, Florida/U.S.A. Tel: (305) 484-8600 Tlx: (510) 955-4261 amd ftl



IBM® *used 64 of these core memory planes in the* 1958 SAGE.

This disk is one of six from a 1956 IBM 1316 *disk pack which stored* 2 *million bits and accessed data at an astonishing* 250*ms.*

AMD's 100*ns* 2M*b* CMOS EPROM *is* 200,000 *times faster and stores the same amount of data as over* 8000 *Selectron tubes in under one centiliter.*

the future CMOS EPROMs.

Now that you have your hands on that bat out of Hell microprocessor, don't let old memories turn your design into a nightmare.

All our CMOS EPROMs are the fastest in their class. And we have the widest range of densities. From our 55ns 64K device to our 100ns 2Mb device. In a configuration that matches any system. Like the one you're designing.

And they're all in power-saving CMOS.

No one makes and sells more CMOS EPROMs than AMD. They're ready, in volume, at prices that won't put bugs in your budget.

Just contact us to find out how AMD can make wait states a mere memory for you.

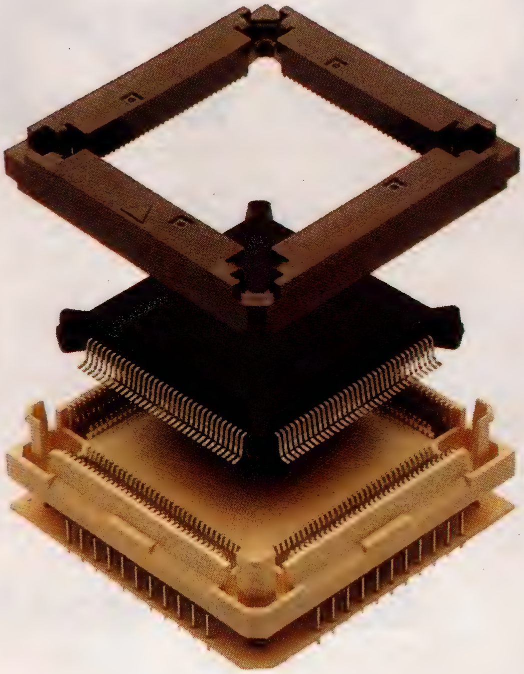
Advanced Micro Devices

For more information write "CMOS EPROMS" on your letterhead and mail to: (In Europe) AMD Mail Operations, P.O. Box 4, Westbury-on-Trym, Bristol BS9 3DS United Kingdom (In Asia) Advanced Micro Devices Far East Ltd., Rm. 1201-2 Harcourt House, 39 Gloucester Road, Hong Kong, Attn: Andrew Ng. (In Japan) Advanced Micro Devices Japan Ltd., Shinjuku Kokusai Bldg., 6-6-2 Nishi-Shinjuku, Shinjuku-ku, Tokyo 160, Japan.

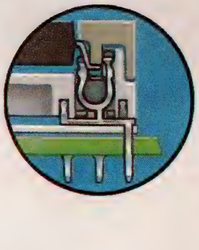
One small step for PQFPs. One giant step for service

Introducing the right technology at the right time—our two-piece Micro-Pitch sockets for JEDEC plastic quad flat pack ICs.

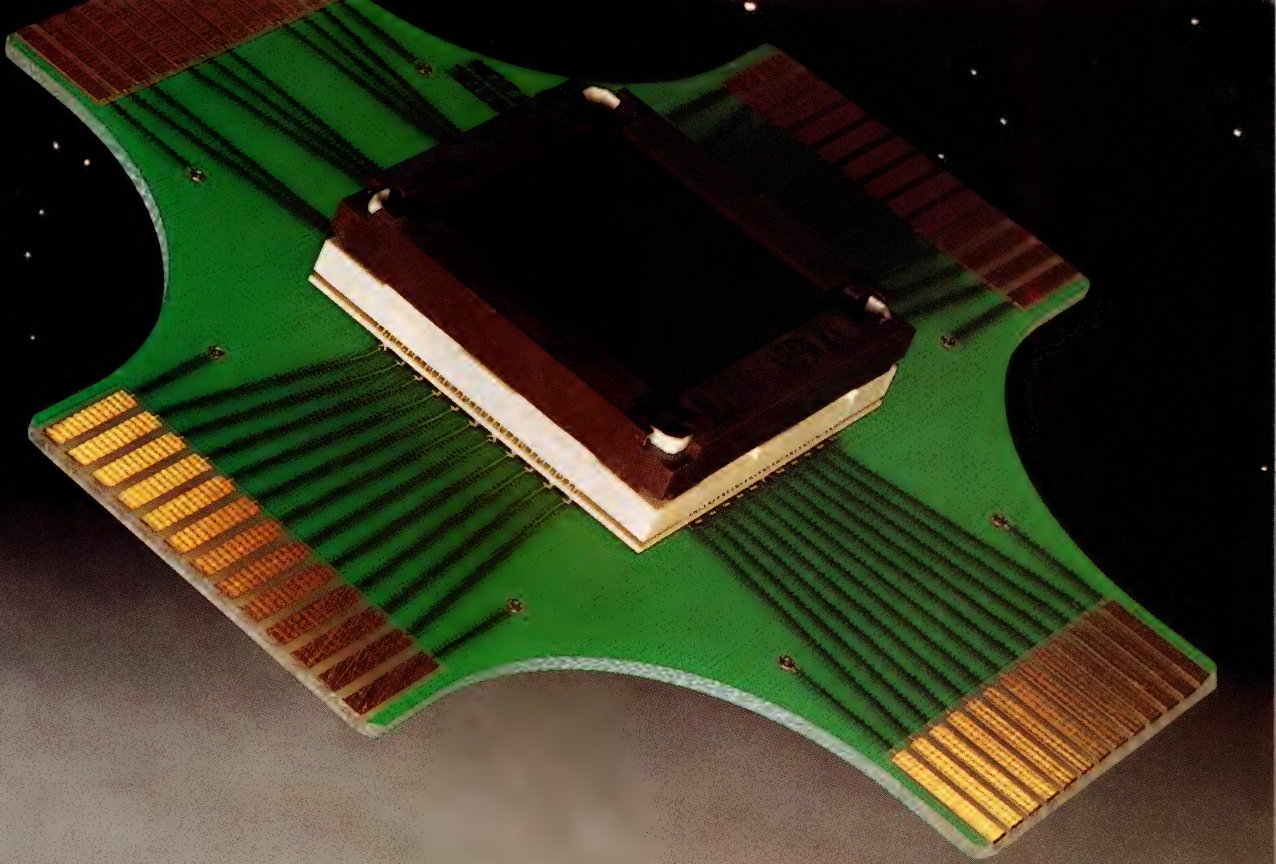
Our patented low-profile (.400″) Micro-Pitch sockets are a remarkably simple, safe way to mount high-speed, high-performance PQFPs. And their simplicity—in engineering, and in the minimum use of material—brings them to you at a remarkably low price.



PQFP as easy as 1-2-3. .025″ centerline Micro-Pitch sockets ease handling, automate readily. High-speed contacts provide oxide cleaning wipe action, 200 grams normal force for positive mating. Footprint on .075″ x .100″ three-row grid.



AMP is a trademark of AMP Incorporated.



and manufacturing.

The cover aligns IC leads for easy insertion into the base. It also protects the leads during handling. In fact, your PQFP supplier can insert chips into covers at his site, and send completed units to you. Result: hands-off installation.

Our high-speed tin-plated contacts provide .020″ to .030″ of contact cleaning wipe during insertion, and a normal mating force of 200 grams on each contact. Very positive engagement. And just the kind of quality engineering you can count on from AMP.

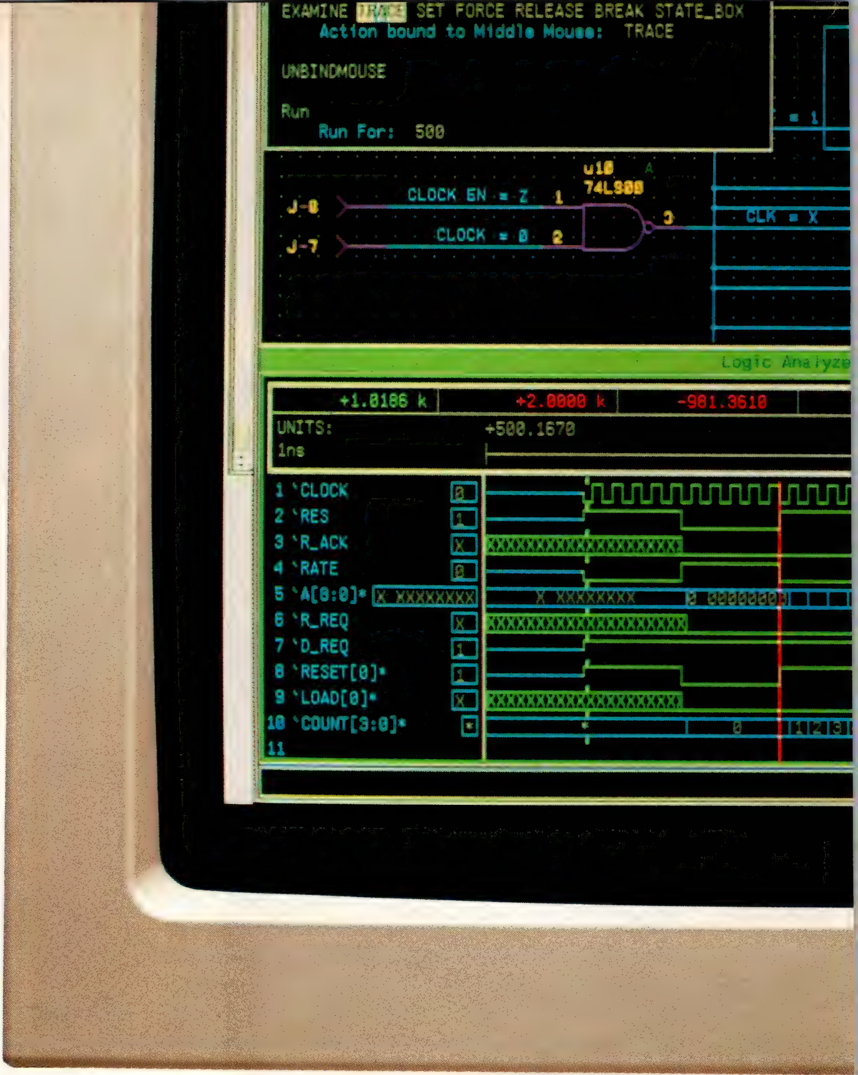
Micro-Pitch sockets have been designed with automation in mind, as well. They're fully polarized cover-to-base, and base-to-board, and compatible with vacuum pickup, for fast robotic implementation.

With today's chip costs, and with the high quality and low installed cost AMP is known for, this is one option you'll want to pick up. Fast.

For technical literature and more information, call the AMP Product Information Center at 1-800-522-6752 and ask about Micro-Pitch Sockets. AMP Incorporated, Harrisburg, PA 17105-3608.

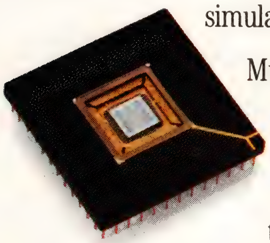
AMP Interconnecting ideas

CIRCLE NO. 80



CAE for people to see how their

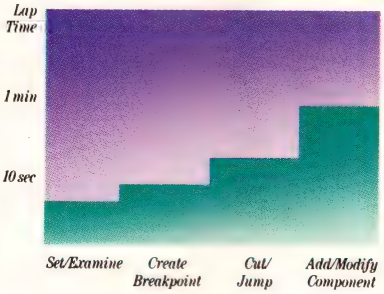
If your CAE tools are telling you too little too late, consider this news from Teradyne. Now you can capture and analyze complex ASIC and VLSI board designs with unprecedented accuracy and ease, using our Vanguard™ schematic entry software and LASAR simulator in Teradyne's MultiSim™ environment.



LASAR's accurate worst-case timing analysis means you won't be held up by faulty prototypes.

Here are CAE tools that work the way you like to work. They'll help you move quickly between schematic and simulation, and let you control simulation interactively. You'll get immediate feedback at every step.

Click on nodes you want to monitor and watch signal activity "live" on the schematic or in the logic analyzer window. By setting breakpoints, you can freeze the action when results aren't what you expect. In no time, you'll know where your design is working and where it's not.

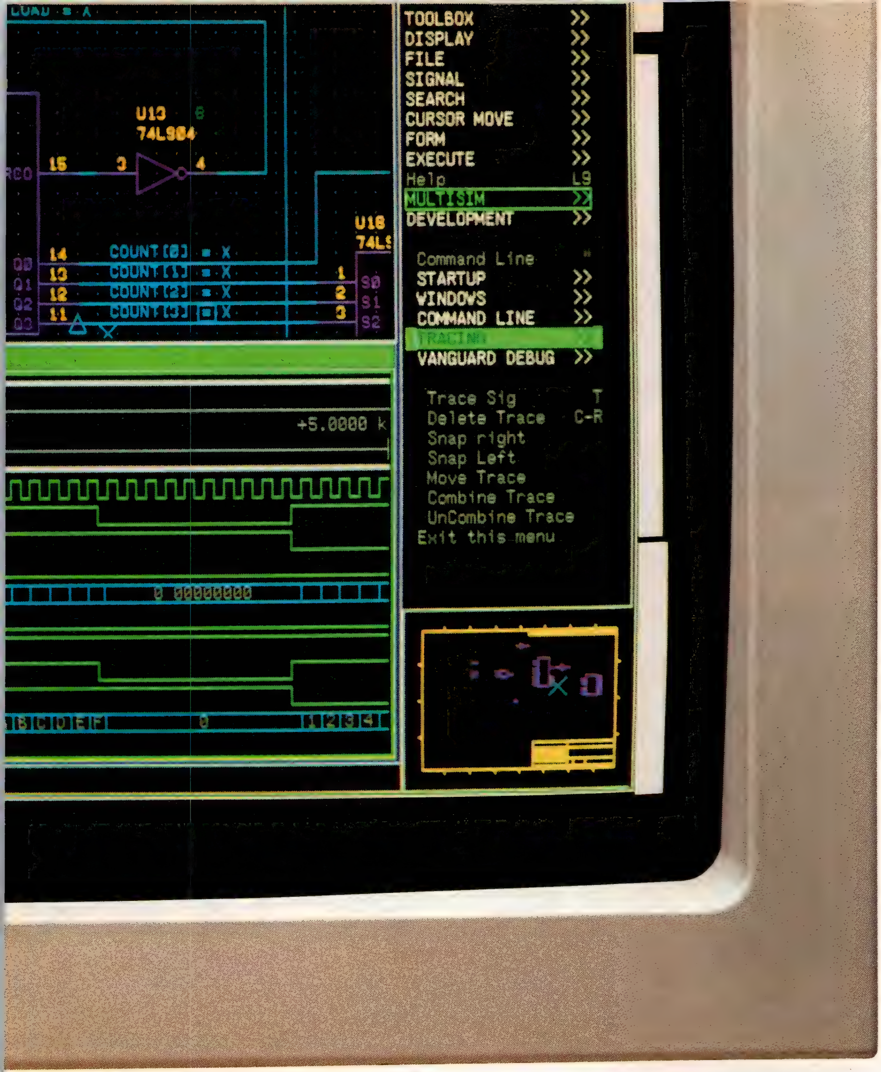


If you find a problem, fix it and see the results in seconds, because we eliminate compilation for most common design changes.

Got a glitch? Need to invert a signal? Make cuts or jumps on schematic interconnections. Add or delete components. You'll see the effects of design changes instantly because we shortcut compilation for the modifications you make most frequently. This means you can try out "what-ifs" with record speed, reducing design-loop time from tens of minutes to tens of seconds.

Best of all, with CAE tools from Teradyne you can be sure that what

MultiSim and Vanguard are trademarks of Teradyne, Inc. VAX is a trademark of Digital Equipment Corporation. Sun is a registered trademark of Sun Microsystems, Inc.



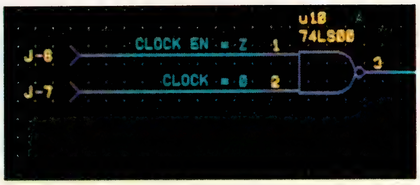
who can't wait designs work.

you see in design is what you'll get in manufacturing. How so? Because our LASAR system is more accurate than other event-based simulators. LASAR's worst-case algorithms precisely simulate the operation of gate arrays, high-speed micros and time-multiplexed buses, including the effects of process variations. You can zero-in on troublespots efficiently, and be confident that LASAR-verified designs will work—reliably and repeatably.

If you're in a hurry for results, you'll appreciate how easily Teradyne tools integrate into your current design process. EDIF, VHDL and commercial-tool interfaces let you build on existing databases. Then tie all your design and analysis tools running on PCs, Suns® or VAXs™ into one multiwindow design environment using Vanguard's graphical framework.

So don't wait. For more information about how our CAE tools can work for you, call Daryl Layzer at (617) 482-2700, ext. 2808. Or write Teradyne, 5155 Old Ironsides Drive, Santa Clara, CA 95054.

The same user interface and file format on PCs, Suns and VAXs simplifies training and communications when you're mixing platforms.

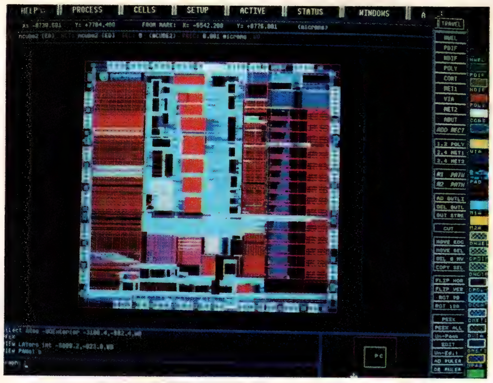


Interactive commands execute instantly so it's easy to try out new ideas.

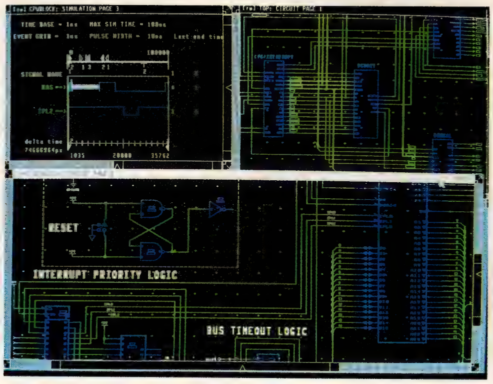
LASAR lets you combine structural, behavioral, and hardware models for simulation efficiency with exceptional accuracy.

TERADYNE

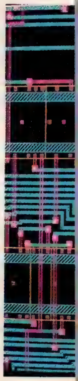
CIRCLE NO. 81

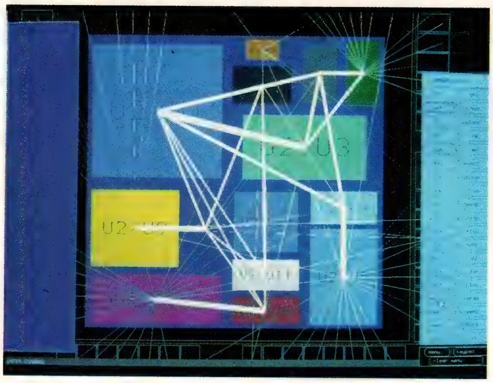


Mentor Graphics delivers a broad line of integrated EDA software, including advanced custom and semicustom IC tools.



HP DesignCenter provides integrated tools for digital, analog, and microwave circuits, as well as ME CAD and CASE.

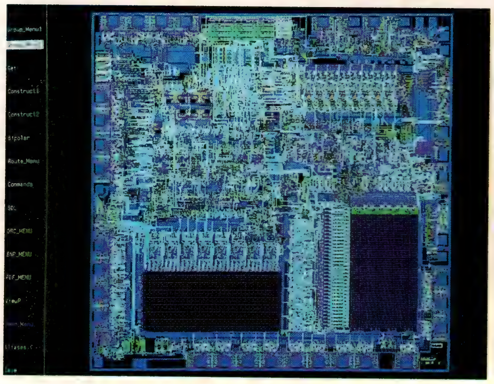




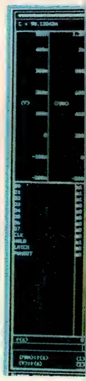
LSI Logic's FloorPlanner™ tool is used for designing a broad range of complex ASICs.

Come to us
We've tried

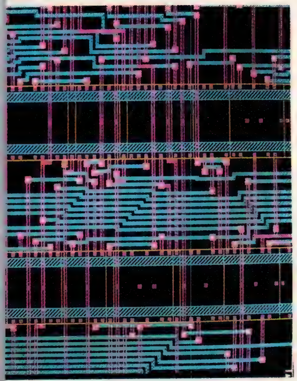
Pacific Numerix concurrent engineering solutions simulate the performance and manufacturability of PCB designs.



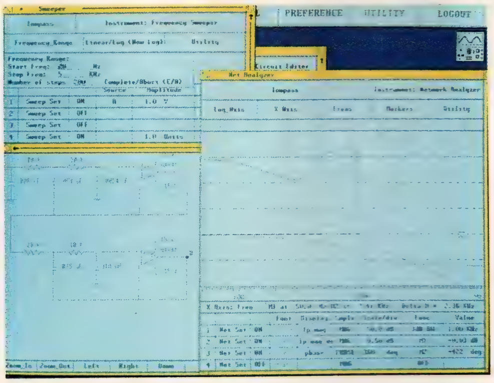
Silicon Compiler Systems' ASIC and IC design tools support all phases of design in an open framework.



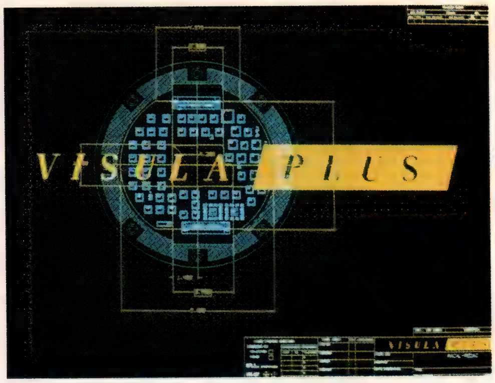
© 1990 Hewlett-Packard Company CPEG919



Cadence Design Systems rovides high-performance IC esign tools in an integrated design environment.

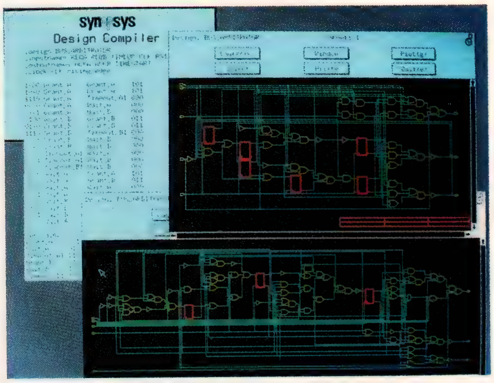


Valid's Analog Workbench™ features an integrated environment for the design and simulation of analog circuits.

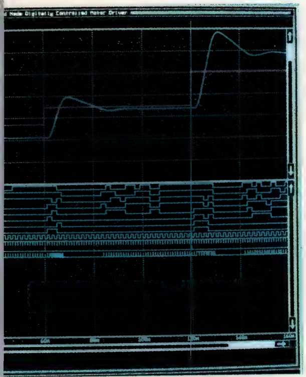


Racal-Redac's Visula™ EDA system provides tools for quality design through manufacturing.

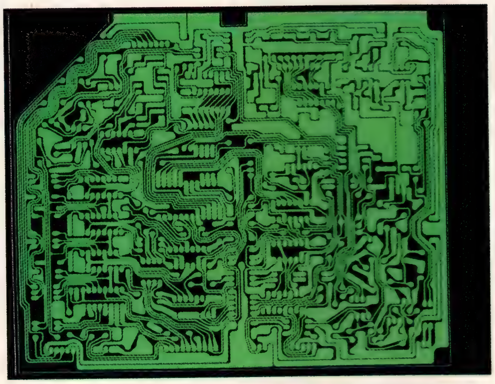
for advice.
everything.



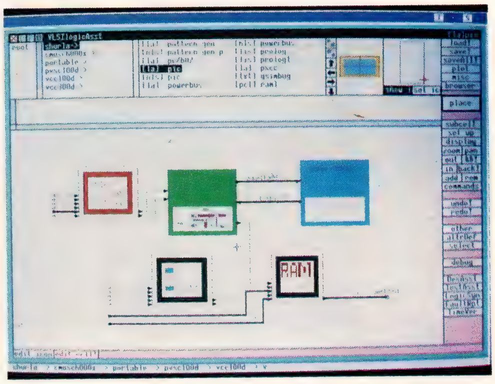
Synopsys Design Compiler™ extracts state tables from netlists and optimizes state assignments to reduce gate count.



Analogy's® Saber™ simulator handles both analog and digital circuits, as well as nonelectrical devices.



Zuken America's CR-3000 system for analog PCBs offers true curves and arcs on the screen and in the database.



VLSI Technology's V8 ASIC Design Platform™ significantly speeds time-to-market and optimizes device performance.

At Hewlett-Packard, we've been automating our electronic design process for years. And we've faced the same problems you've faced. Time to market. Productivity. Profitability. All of them.

That's why we now have a better way.

Together with our software suppliers, we offer the broadest EE application selection in the industry. And the strongest commitment to helping your team find, evaluate, and implement the right EDA tools for the task at hand.

Our goal is to give you solutions that support your entire product development cycle. Solutions that get your products to market faster and lead to increased profitability.

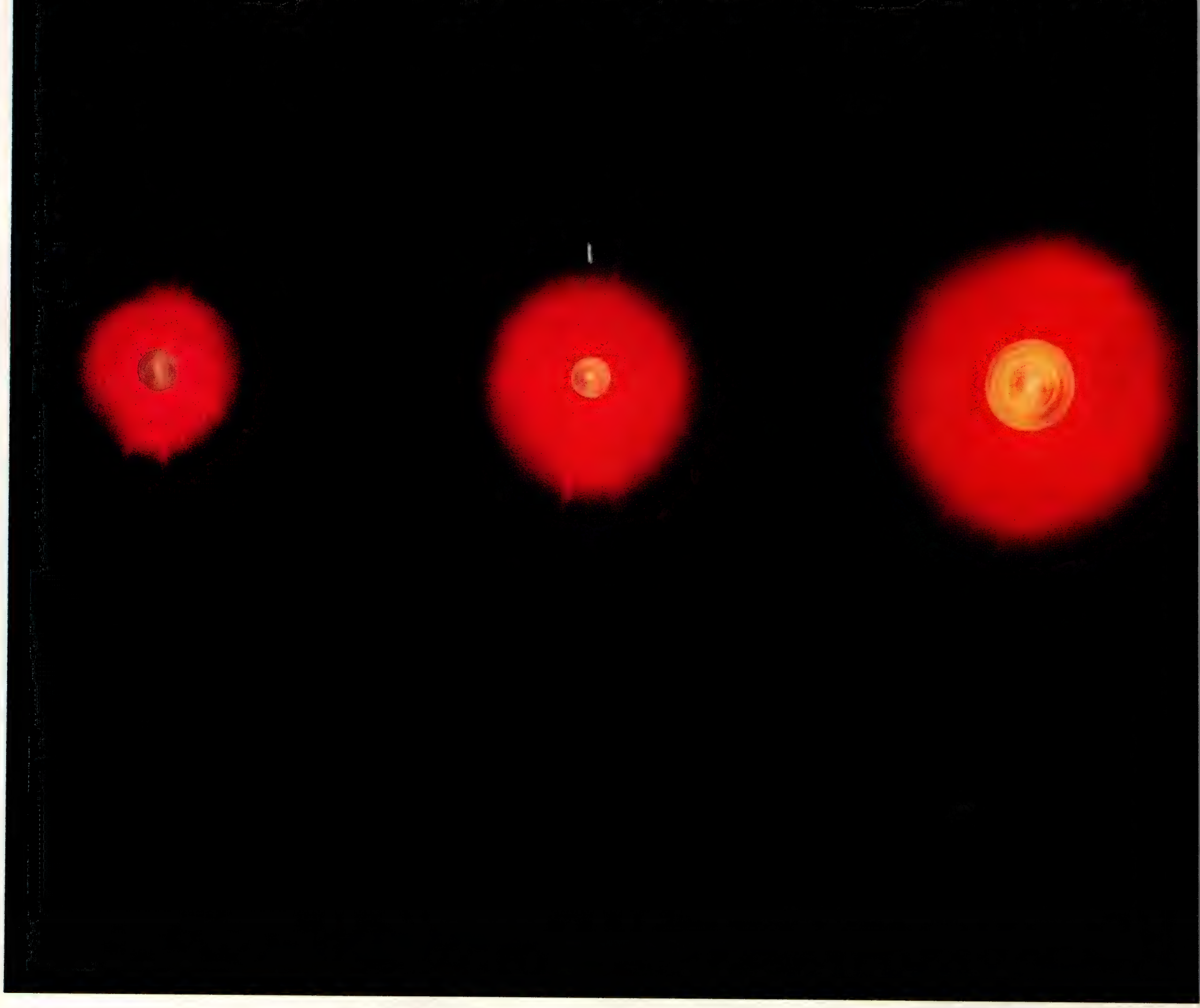
To arrive at the right solutions for your next design project, start with the workstation vendor that has them and knows how to use them. Call HP today at 1-800-752-0900, Ext. 219W.

There is a better way.

HEWLETT PACKARD

CIRCLE NO. 82

Introducing Bright, Brighter and Brightest.



When it comes to high-intensity LED performance, HP can make you shine. In fact, we've got the brightest new ideas in TS-AlGaAs technology.

Our new TS-AlGaAs lamps combine HP's proven high-flux TS-AlGaAs technology with an advanced optical design to deliver unsurpassed LED performance.

What's more, HP is the only U.S. company who can provide you with the broad range of LED technology you need for all your high-intensity applications. And the only company anywhere who can deliver the world's brightest LED performance.

You can choose the HLMP-8103 or HLMP-8104. Both are standard-size TS-AlGaAs lamps, designed to provide very high intensity. The HLMP-8103, our 3 cd lamp, has a maximum intensity of 5.8 candelas. For an even brighter lamp, the HLMP-8104, our 4 cd lamp, delivers a maximum intensity of 8.4 candelas.

The HLMP-8150 TS-AlGaAs lamp has a maximum intensity of 25 candelas. Which makes it the brightest LED lamp in the world.

If your application calls for a high-intensity lamp with a wider viewing angle, HP's HLMP-8100 provides an angle of 24 degrees.

All of which makes HP's new TS-AlGaAs lamps the perfect choice for exterior moving message signs, exterior automotive lighting, incandescent replacement and sensors.

Best of all, they're from HP. So you're always assured of HP's commitment to excellence in service, support and reliability.

For a free sample, call **1-800-752-0900, ext. 428Q**. We'll introduce you to the brightest new ideas in LED performance.

There is a better way.

HEWLETT PACKARD

CG08002

CIRCLE NO. 83

NEWS BREAKS

EDITED BY JULIE ANNE SCHOFIELD

VMEBUS CPU CARD SPREADS WINGS

Force Computers' (Munich, Germany, FAX (89) 6097793) 68040-based VMEbus CPU-4X series cards add memory or other functions using daughter boards and occupy a single backplane slot. The function daughter boards let you add SCSI, Ethernet, floppy-disk, or VME-subsystem-bus (VSB) interfaces. You can also use these boards to add an X.25 extension. The memory daughter board holds either a 16M-byte dynamic RAM or a 4M-byte static RAM (SRAM). The common base card provides four serial I/O channels, an 8-bit parallel I/O channel, a real-time clock, and one 8- and two 24-bit timers. Standard memory includes a maximum of 2M bytes of 32-bit-wide, 200-nsec EPROM; 32k bytes of battery-backed SRAM; and boot EPROM. The cards should be available the third quarter of this year for £4950. —Brian Kerridge

RESOLVER-TO-DIGITAL CONVERTER HAS THREE CHANNELS

A 3-channel hybrid 16-bit resolver-to-digital converter will be available from Natel Engineering Co (Simi Valley, CA, (805) 581-3950) in May. The HRD1346 converter is housed in a 40-pin 0.9-in.-wide DIP and operates from a single 5V dc power supply to prevent ground-loop problems. All three channels are totally independent and have 1.3-arc-minute accuracies. The part will cost $1495.—Doug Conner

SINGLE-BOARD COMPUTER OFFERS STD BUS COMPATIBILITY

You can now order a 16-MHz 80386SX-based single-board computer for your embedded STD Bus applications. With an onboard Phoenix Computer Products (Norwood, MA, (617) 762-5030) BIOS and a Chips and Technologies (San Jose, CA, (408) 434-0600) Neatsx chip set, the MCM-386SX board from WinSystems (Arlington, TX, (817) 274-7553) provides 100% IBM PC/AT compatibility. This $1795 board measures 4.5×6.5 in. and has 512k bytes of dynamic RAM, 256k bytes of EPROM storage, 15 interrupt channels, two RS-232C channels, a Centronics parallel I/O port, a real-time clock, two DMA channels, a watchdog timer, three 16-bit counter/timers, and an 8/16-bit STD Bus interface.—J D Mosley

REPROGRAMMABLE PLDs EXPAND 22V10 FAMILY

Two reprogrammable PLDs build on the GAL22V10 family from Lattice Semiconductor Corp (Hillsboro, OR, (503) 681-0118, FAX (503) 681-0347) to give you more choices when using the 22V10 PLD architecture. The GAL18V10 and GAL26CV12 are, respectively, 20-pin and 28-pin versions of the 24-pin GAL22V10. The $12.33 (100) GAL18V10 contains eight dedicated input pins and 10 bidirectional I/O pins. The $24.64 (100) GAL26CV12 features 14 input pins and 12 I/O pins. With this 3-part family, you can select the number of inputs and I/O pins you need to more closely match your requirements. Lattice's GALs employ EEPROM technology for device programming, which lets the company run complete functional and parametric testing on every device it ships.—Steven H Leibson

NEWS BREAKS

CLEAN PC BOARDS WITH CFC SUBSTITUTE

A panel of 230 industry and government researchers organized by the Environmental Protection Agency has identified Genesolv 2010, developed by Allied Signal (Morristown, NJ, (201) 455-2000), as a chlorofluorocarbon (CFC) substitute that cleans pc boards as well or better than CFC-113 but poses less of an environmental threat. CFC-113 is a cleaning solvent widely used in the electronics industry, but, as a CFC, releases chlorine into the atmosphere. Researchers have implicated human-generated chlorine in the depletion of Earth's protective ozone layer. As a result, the US and several other nations are phasing out production of CFC-113 as part of an international agreement called the Montreal Protocol.

Genesolv 2010 is a blend of hydrochlorofluorocarbons (HCFCs), alcohol, and stabilizers. HCFCs do release chlorine into the atmosphere, but because they remain in the atmosphere for a much shorter time than CFCs, they release much less chlorine. The panel recommended that the Department of Defense revise its military specifications to allow the solvent to replace CFC-113 for cleaning pc boards once the EPA approves the solvent for commercial use.—Julie Anne Schofield

Z80 μP HITS 20 MHz

After nearly 15 years on the market, the Z80 μP still keeps chugging along. The latest version of this venerable 8-bit part, the Z84C0020, runs at 20 MHz and retains full code compatibility with its predecessors. You can get samples of the device from Zilog Inc (Campbell, CA, (408) 370-8000, FAX (408) 370-8056) for $18.
—Steven H Leibson

INSTRUMENT MAKER RETAINS LOW-CURRENT FOCUS

Despite its strong presence in PC-based instrumentation, Keithley Instruments (Cleveland, OH, (216) 248-0400) is not turning its back on low-current measurements, the area of instrumentation on which it originally built its business. The company announced three new products, the 428 current amplifier ($2995; $3495 with IEEE-488 interface), the 486 picoammeter ($1995), and the 487 picoammeter/voltage source ($2995). The 428, whose maximum transresistance is 10^{11} V/A, has a 10 to 90% rise time of 2 μsec on its least sensitive range. This spec is five times as fast as that of competitive instruments.—Dan Strassberg

ECAD COMPANIES UNITE

More than 80 electronic CAE/CAD companies have joined forces to create EDAC (Electronic Design Automation Companies) (Santa Clara, CA, (408) 987-4291), an organization whose charter is to promote the value of automating electronic design in competitive world markets. Rather than compete with existing organizations that define standards and specifications, EDAC intends to focus on policy-making to encourage industry growth. Electronic-design-automation companies interested in becoming charter members should contact the organization by April 1, 1990. EDAC's membership ranks already include most of the biggest EDA companies and many of their smaller competitors.—Michael C Markowitz

Thanks to us the government knows this is not an enemy sub.

Here in the lonely depths off America's coast, sophisticated listening devices assure our defense forces a passing butterfly fish is not an enemy intruder.

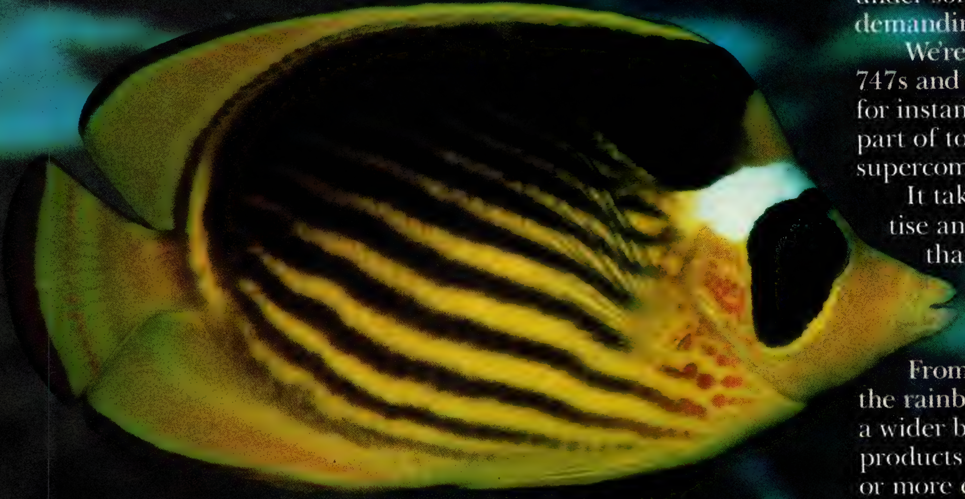
On board each device are ITT Cannon microminiature connectors.

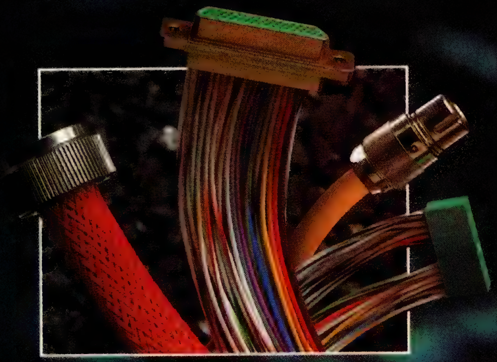
In fact, you'll find Cannon microminiature connectors performing in some of the nation's most critical projects, under some of the world's most demanding conditions.

We're in pacemakers, 747s and Minuteman missiles, for instance. And we're part of today's advanced supercomputers.

It takes the design expertise and innovative solutions that ITT Cannon offers to meet these types of challenges. And yours.

From under the sea to over the rainbow, no one provides a wider breadth of connector products at competitive prices or more engineering know-how. Maybe that's why we've been the leading force in microminiature technology for over 25 years running.





So why fish around for a connector company when you can enjoy the depth and strength of the leader. ITT Cannon.

For application assistance or to request our new brochure, call us at (714) 557-4700 today.

Or write ITT Cannon,
666 E. Dyer Rd., P.O. Box 929,
Santa Ana, CA 92702-0929
FAX: (714) 754-2142.

ITT Cannon
AN ITT EMC WORLDWIDE COMPANY
Discover our strengths.

CIRCLE NO. 84

NEWS BREAKS

PLUG-ON MODULES ENHANCE VMEBUS ANALYZER

Five plug-on modules enhance the capabilities of the $5990 VBT-321 Advanced VMEbus Tracer, a board-level bus analyzer for the VMEbus from VMetro (Oslo, Norway, (47-2) 39 46 90, FAX (47-2) 18 39 38, and Houston, TX, (713) 266-6430, FAX (713) 266-6919). The $4250 VSB-PB extends the analyzer's coverage to include the VME subsystem bus. The $3550 TIM100-PB adds 100-MHz, asynchronous timing analysis for 95 VMEbus signals. Two memory modules, the $1000 XM64-PB and the $4000 XM256-PB, increase the analyzer's trace buffer from 2k words to 64k and 256k words, respectively. Finally, the $2450 VBAT-PB, a module introduced last year, monitors the bus and triggers the analyzer when any of several possible timing violations, as defined by the VMEbus spec, occur on the bus. Together, these six products comprise a modular system that lets you tailor a VMEbus analyzer to your requirements.—Steven H Leibson

WOMEN ENGINEERS AND SCIENTISTS TO CONFER

The University of Warwick (Coventry, UK) will host the Ninth International Conference of Women Engineers and Scientists (ICWES 9) on July 14 to 20, 1991. The subject is communications. The conference will include such wide-ranging topics as sensors, satellites, and computing, but will also address social issues affecting both developed and developing nations. The meeting will spotlight the international achievements of women engineers and scientists. Send your offer of papers or request for details to Conference Services, ICWES 9, 55 Cavendish St, London W1M 7RE, UK. FAX (01) 935 7759.—Brian Kerridge

BENCHTOP ASIC TESTER FEATURES VARIABLE SLEW RATE

At less than $1000/pin, HiLevel Technology Inc's (Irvine, CA, (714) 727-2100) ETS 7000 benchtop ASIC test and verification system makes in-house ASIC testing affordable for small companies and engineering departments. The tester operates at speeds as fast as 100 MHz and offers features such as programmable loads and automatic calibration. The tester can vary slew rates from 0.2 to 1.5V/nsec and lets you test devices fabricated with virtually any technology. The basic system costs $934/pin and includes the tester chassis, a system controller (essentially an 80386-based personal computer), and IBM VGA color graphics. The chassis can accommodate eight 16-pin test modules for a maximum configuration of 128 pins. The ETS 7000 is available 60 days ARO.—Maury Wright

DESKTOP CARTRIDGE SYSTEM STORES 50G BYTES

At 8.5×15.5×16.5 in. and 25 lbs, the EXB-10 cartridge-handling subsystem from Exabyte Corp (Boulder, CO, (303) 442-4333, FAX (303) 442-4269) has a prodigious data-storage capacity that belies its small size. It holds 10 8-mm, 5G-byte tape cartridges for a maximum capacity of 50G bytes. It also holds one of the company's 8-mm cartridge-tape subsystems for recording data and reading the tapes. A robotic picker shuttles cartridges between storage slots in the EXB-10 and the tape drive in less than 20 sec. At full speed, the unit can accept information for 28 hours without stopping. The EXB-10 costs $2995; this price does not include the cost of the tape cartridges or drive.—Steven H Leibson

Chips, lead frames, carriers and molding compound can't lift you out of the crowd.

Dale® Can.

Dale® is the partner you need to convert surface mounting from concept to reality. We can save you time by providing a wide range of functions from one proven source.

This includes the industry's most versatile choice of surface mounted thick and thin film chip resistors and resistor networks. Plus wirewound resistors, chip potentiometers, thermistors, inductors, transformers and oscillators.

Partnering with Dale gives you broad compatibility with automatic placement equipment and standard soldering methods, plus ship-to-stock capability assured by strong emphasis on statistical process control.

For complete information, call: **Thick Film Resistor Networks, Thermistors:** 915-592-3253; **Thin Film Networks, Thick/Thin Film Chips:** 402-371-0080; **Wirewound Resistors:** 402-563-6506; **Chip Potentiometers, Oscillators:** 602-967-7874; **Inductors, Transformers:** 605-665-9301.

DALE®

Dale Makes Your Basics Better

DALE ELECTRONICS, INC.
. . . a VISHAY Company

CIRCLE NO. 85

THE WORLD'S LARGEST MANUFACTURER OF POWER SPLITTERS/ COMBINERS

2 KHz to 8 GHz from $\$10^{45}$

With over 300 models, from 2-way to 48-way, 0°, 90° and 180°, a variety of pin and connector packages, 50 and 75 ohm, covering 2KHz to 8000MHz, Mini-Circuits offers the world's largest selection of off-the-shelf power splitter/combiners. So why compromise your systems design when you can select the power splitter/combiner that closely matches your specific package and frequency band requirements at lowest cost and with immediate delivery.

And we will handle your "special" needs, such as wider bandwidth, higher isolation, intermixed connectors, etc. courteously with rapid turnaround time.

Of course, all units come with our one-year guarantee.

For detailed specs and performance data, refer to the MicroWaves Product Directory, EEM or Mini-Circuits RF/IF Signal Processing Handbook, Vol. II. Or contact us for our free 68-page RF/IF Signal Processing Guide.

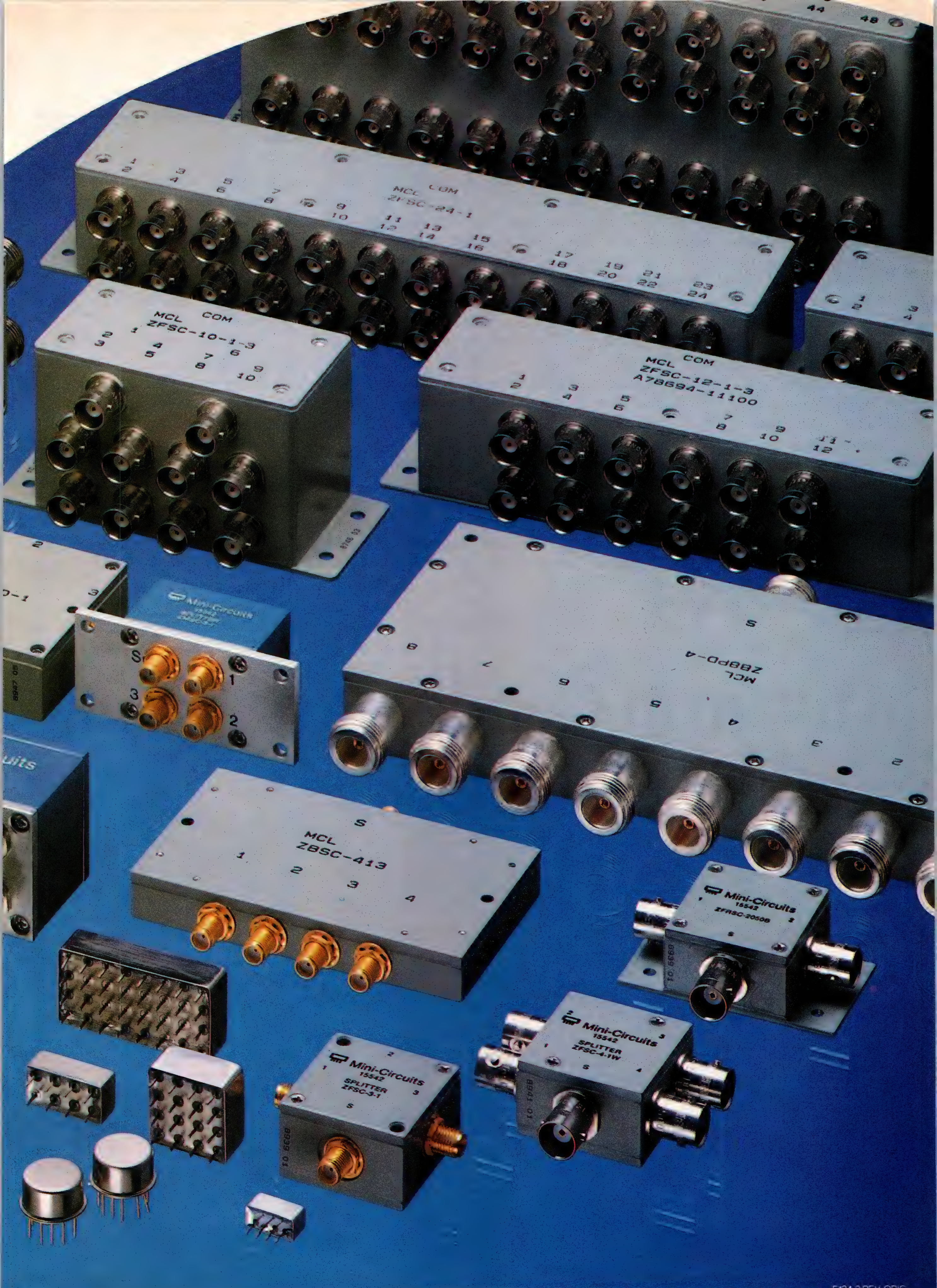
finding new ways ...
setting higher standards

Mini-Circuits

A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156
WE ACCEPT AMERICAN EXPRESS

CIRCLE NO. 86

F134-1 REV. ORIG.



F134-2 REV. ORIG

SIGNALS & NOISE

Questions about limiting noise in CMOS logic

I read the recent article by William Hall and Charles Pace, "Limit Noise in Designs Using Advanced CMOS Logic" (EDN, November 9, 1989, pg 215) with interest because it pertains to a recent problem I experienced with a CMOS microcomputer system, which would "crash" once or twice a week for no apparent reason. To improve the noise immunity of this system, ceramic bypass capacitors were installed in strategic locations as close to package pins as possible. The bus transceiver devices and the microprocessor itself were identified as the devices most in need of this supplement to the conventional digital bypass network, which was thought at first to have been more than adequate.

In addition, a single sentence in the article (on pg 218, last paragraph) left me scratching my bald head in disbelief. Experience has taught me to obey the often quoted conventional wisdom to place a low-loss, low-inductance capacitor as close to each IC as possible, to take care of high-frequency power-line "noise," and to distribute bulk capacitance on the circuit board—that is, tantalum or aluminum electrolytic—to prevent dropout from current surges.

The line in the article recommends a single 0.1-µF tantalum capacitor to decouple each surface-mount CMOS octal line driver, saying "Decouple every driver with a 0.1-µF tantalum capacitor and place them as close as possible to the driver's ground pin." The reasons behind this choice of capacitor are not stated in the article and are not obvious to me in light of the need to minimize series inductance in this application. Nor is it clear to me whether the authors would use the specified tantalum capacitor for CMOS drivers that were not in surface-mount packages.

I would very much appreciate an answer from the authors of the article. I've read your magazine for many years and some of the articles have been real lifesavers.

Thomas C Bickler
La Canada, CA

(The authors' reply:) Thomas Bickler raises two questions regarding our article, "Limit Noise in Designs Using Advanced CMOS Logic" (EDN, November 9, 1989, pg 215): Why is a tantalum capacitor recommended for decoupling? and why is decoupling recommended only for

You're In Good Company with C&K Switchlocks.

When you are in need of value added switchlocks, come to C&K. You'll be in good company with IBM, Wang, Telex and Zenith. If you want to control computer access, point-of-sale terminals, test instruments, medical equipment, process control systems, security and/or alarm systems, C&K can provide the right combination at the right cost to meet your specifications. Send us your specs and we'll send you a free engineering sample.

Sales/Customer Service Direct: (800) 334-7729
In NC: (919) 553-3131
Telex: 579385 • Fax: (919) 553-4758

C&K® C&K Components, Inc.
Clayton Division
2035 Highway 70 East
Clayton, NC 27520-0687

The Primary Source Worldwide®...

"But there's not enough time to order all the special panel indicators we need!
Now what?!"
DIALCO
QUAN.
PART NO.
DIALIGHT
5100-
All indications are Dialight.

The customer was an electronics firm known for his highly specialized, custom equipment. He had the proprietary technology; his problem was getting a wide range of custom indicators to match. And his newest product was due for immediate release. That's when he called Dialight.

As the leader with over half a century of experience in every type of indicator light, for Dialight solving problems is standard operating procedure. We provided incandescent, neon and LED panel indicators in every shape, size and color; each with performance properties that highlighted his proprietary systems. We let him limit quantity, but as always, delivered limitless quality. And we did it at better prices than he had been getting for his quantity orders.

Offering a vast assortment of panel indicators right off the shelf isn't all that makes Dialight right. Over the years customers have asked us to make them with integral resistors, light shielded, RFI/EMI shielded, front mounted, rear mounted, relampable, oil-tight, water-tight, MIL-spec'ed, just about any way you can imagine and we haven't been stumped yet!

So, the next time you have a need for indicators, be they incandescents, neons or LEDs, either customized or from our incredible off-the-shelf selection, remember that no one has more solutions than Dialight.

DIALIGHT CORPORATION
A Cambridge Electronic Industries Co.
1913 Atlantic Avenue, Manasquan, NJ 08736   201-223-9400

CIRCLE NO. 87

surface-mount devices?

The article errantly calls out the use of tantalum decoupling capacitors for each advanced CMOS device. The proper choice should be ceramic (if possible, chip type) capacitors. Tantalum ESR (equivalent series resistance) is as much as 10 times greater than ceramic, making tantalum much noisier. In addition, tantalum is more costly than ceramic. Tantalum does have a lower dielectric constant, making it less sensitive to temperature variation; and tantalum is useful when large capacitance (greater than 10 μF) is needed, such as decoupling where power enters the board. Ceramic, however, is the proper choice for most localized device decoupling jobs.

Tom's second point is a misinterpretation of the paragraph on minimizing internal rail noise. A sentence in the middle of the paragraph states: "In designs utilizing surface-mount devices, where there are no pins to solder directly to power planes, keep the V_{CC} *and ground connections short." This is a stand-alone sentence. Tom and perhaps other readers interpreted the rest of the paragraph to apply only to surface-mount devices; however, all sentences in the rest of the paragraph apply equally to surface-mount and through-hole packaging. Therefore, we do indeed recommend decoupling all package types with 0.1-μF ceramic capacitors. We regret any confusion (and/or loss of hair) this paragraph has caused for EDN readers.*

We thank Tom Bickler for drawing these points to our attention and hope these issues are now clarified. Proper decoupling is extremely important in advanced CMOS design and, as Tom points out, could bring a crashing system back to life.

Oops! Wrong picture

S-MOS Systems (San Jose, CA) points out that the photograph on pg 169 of the December 21, 1989, issue of EDN does not represent the S-MOS Systems NavNet ASIC-design package; it is in fact a picture of the PADS-Logic schematic-capture package from CAD Software (Littleton, MA). EDN apologizes to both companies for the error.

WRITE IN

Send your letters to the Signals and Noise Editor, 275 Washington St, Newton, MA 02158. We welcome all comments, pro or con. All letters must be signed, but we will withhold your name upon request. We reserve the right to edit letters for space and clarity.

AT YOUR COMMAND.

Data Acquisition and Instrument Control at Your Fingertips

With the CEC genie your wishes come true. You can control any IEEE-488 (HP-IB, GP-IB) instrument, printer, or plotter from your PC. CEC's plug-in cards come with a software library of example programs and utilities that let you spend more time solving problems than programming. CEC provides software support for BASIC, Pascal, C, and FORTRAN.

If your wish is for a custom program, CEC also offers software that writes '488 programs.

Simply pop up our software over your program editor and choose a control function or library for your instrument. Code is automatically generated from your choices. Press a key and the magic begins. The code appears where you want it in your program.

Now, make your wishes come true by calling 800-234-4232 for your FREE demo disk.

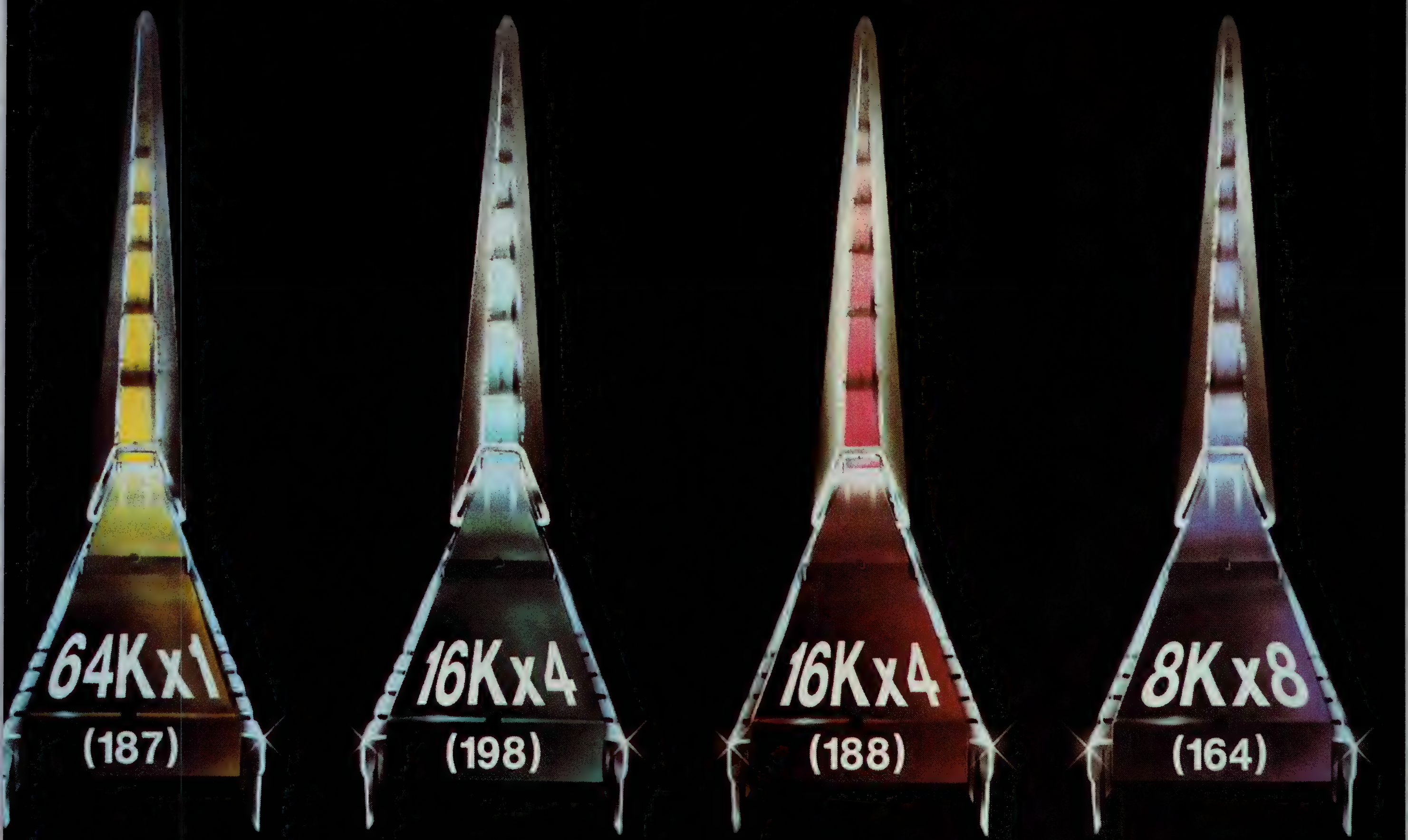
cec

Capital Equipment Corp.

99 South Bedford Street
Burlington, MA 01803
Tel: 617-273-1818 Fax: 617-273-9057

CIRCLE NO. 2

PERFORMANCE
means the FASTEST 64K SCRAMS



10ns (x1)
12ns (x4)
15ns (x8)

Performance's CMOS 64K SCRAMs (Static CMOS Random Access Memories) are the industry's fastest — as fast as 10ns for x1, 12ns for x4, and 15ns for x8 configurations.

These SCRAMs are ideal for data-bus-intensive RISC and CISC processors. They have extremely fast output enable times to permit fast data bus turnaround for high system throughput. *Also available are x4 SCRAMs with separate I/O.*

At Performance, SCRAMs are manufactured in a six-inch Class 1 fabrication facility using PACE II (0.7 micron gate length) technology which has set the standard for memory speed.

All Performance 64K SCRAMs are available now in DIP, SOJ, and LCC packages.

64K SCRAMs AVAILABLE NOW

PART	CONFIGURATION	SPEED
P4C187	64Kx1	10ns
P4C188	16Kx4	12ns
P4C198	16Kx4 W/OE	12ns
P4C164	8Kx8 W/OE	15ns

FAST, COOL & AFFORDABLE

To get Performance's Data Book, more information, or to order 64K SCRAMs, call or write:

Performance Semiconductor
610 E. Weddell Drive, Sunnyvale, Ca 94089
Telephone: 408 734-9000
FAX: 408 734-0258

PERFORMANCE
SEMICONDUCTOR CORPORATION

CIRCLE NO. 88

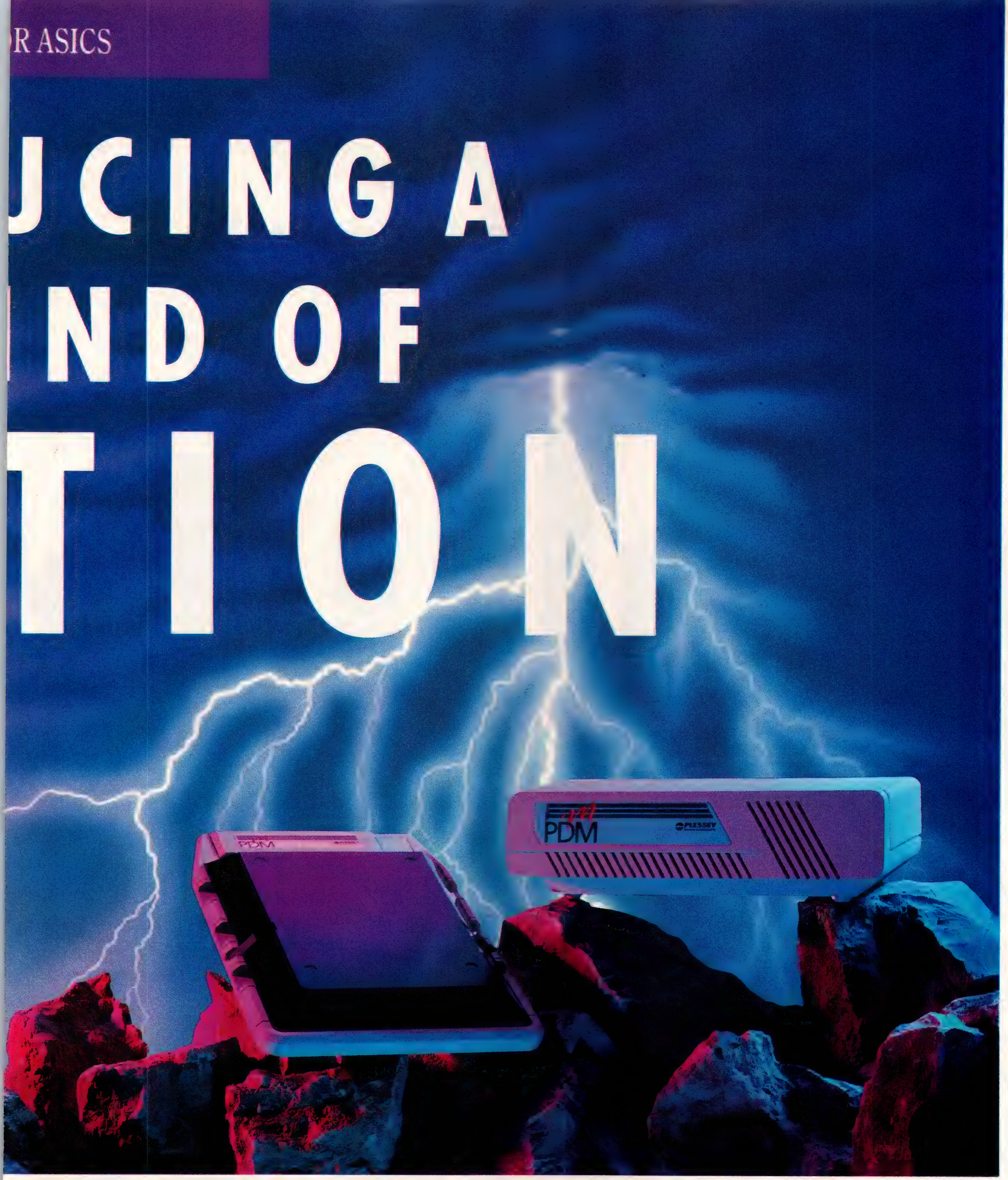
PLESSEY
Semi Custom
PDM

For too long now, designs combining analog and digital signals have restricted the design engineer in what he can do – and how quickly he can do it. Even with simulators, design routes have been long on frustration and short on true effectiveness.

Enter PDM from Plessey Semiconductors. The first system to truly enable the engineer to test his design at all stages BEFORE committing to silicon. Often within 28 days, instead of a hit and miss 12 weeks.

With PDM, the engineer can say goodbye to the problems

Plessey Semiconductors Offices located in: Australia, Austria, Belgium, Canada, Denmark, Finla
Singapore, Spain, Sweden, Taiwan, Turkey, United Kingdom, United States of America, West Germ



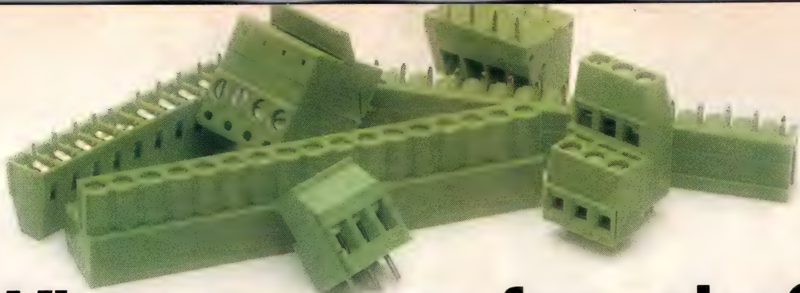
that come with chip design in mixed signal environments. Out goes much of the worry over whether the design will work first time. In comes design cycles that are just about unheard of and at a level of confidence that's equally staggering.

If you're all mixed up with analog and digital signals unscramble yourself by finding out more about PDM. Contact Customer Services on: North America 1 800 441 5665 or Fax: 408 438 7023, elsewhere call 44 793 726666 or Fax: 44 793 518550

PLESSEY
SEMICONDUCTORS

ce, Greece, Hong Kong, India, Italy, Japan, Korea, Malaysia, Netherlands, New Zealand, Norway,
sey Semiconductors Limited is a licensed user of the name Plessey and the Plessey symbol.

CIRCLE NO. 115



Why pay more for color?

BUCHANAN has added 13 new electronic connectors to give you even more options and features...still at lower cost.

Why pay more for competitive green connectors? BUCHANAN electronic connectors give you all the features and flexibility you'll need. And BUCHANAN connectors cost about 15% less. That's the kind of green that counts.

These new one-piece and modular electronic connectors join the growing family of BUCHANAN connectors that already give you the industry's widest range of sizes, shapes, and connection options to choose from . . . with all the high quality, and reliable performance you've come to expect from BUCHANAN engineering.

Here's some of what these newest additions have to offer:

- 13 new series of products, including: One-piece; modular; one piece/modular with test points; one piece subminiature; one piece, double pin; horizontal/vertical plug-in; and screw mounted headers.
- A variety of contact spacing: 3,5/7mm, 5/10mm, and 5,08/10,16mm.
- 5,08mm spacing fits in with CAD/CAM grid.
- Convenient test points for checking continuity provided in rear of selected moldings.
- Other models have lift system wire connection for more secure termination.
- Units are UL/CSA certified; meet VDE 0110 specs.
- Wire range from #12 thru #30 AWG.
- End-to-end mounting with constant circuit spacing.

Here's the bottom line: BUCHANAN connectors give you more for less. More features, more quality, more convenience, more options — for less than the green competition.

So why pay more for the green? Keep your green where it belongs. In your pocket. For all the details on these BUCHANAN electronic connectors designed to let you keep more of that green write for Designer's Guide I/O-400.

amerace

INDUSTRIAL ELECTRICAL
PRODUCTS

AMERACE CORPORATION
INDUSTRIAL ELECTRICAL PRODUCTS
530 W. MT. PLEASANT AVENUE
LIVINGSTON, NJ 07039-1790, (201) 992-8400
TELEX 13-8403 • FAX (201) 992-9416

BUCHANAN®

CIRCLE NO. 89

MAXIM
DESIGN NEWS

Analog Design Insights from Maxim Integrated Products March '90

Maxim Offers All New Analog Design Seminar

Since our last tour in 1989, Maxim has introduced over 60 new products. We invite you to find out what we've been up to in an all **new** applications oriented presentation given by Maxim engineers. Our presentation includes a variety of innovative circuit solutions and previews products soon to be announced.

Seminar Highlights

Switching Regulator Applications

- New Battery Powered Switching Regulators
- Measuring Battery Performance
- Low Voltage Power Circuits
- +5V to ±15V DC-DC Conversion Designs
- DC-DC Conversion for Telecom

Interface Circuits and µP Monitors

- New Isolated Interface Applications
- Improved µP Reset Products
- Reduce Noise in Supply Monitors
- Monitoring Two Power Supplies

Active Filters

- Active Filters With Lowest Noise
- Settling Fast With Lowpass Filters
- Antialiasing for A/Ds and Switched Capacitor Filters
- New Active Filter Applications

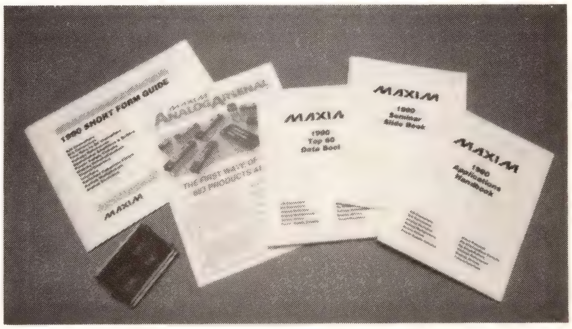
High Speed Analog - Analog Switches, Op Amps, Comparators

- Alternatives for Input Protection
- Low Leakage Multiplexers
- Multiplexer Applications for Low Voltage and Power
- Precision Amplifiers
- New High Speed Op Amps and Comparators
- Single Chip Video Crosspoint Switch

(Please see location and date schedule on back page)

A/D and D/A Converters, Voltage References

- Doing Without Sample-Holds
- DSP Specs Mean What?
- Serial Data Acquisition
- Isolating Data Converters
- New 10 and 12 bit A/Ds
- New Multi-Channel A/Ds
- CMOS Voltage Output DACs



★ Each attendee will receive: ★

- **1990 Applications Handbook**
- **Seminar Slide Book**
- **1990 Shortform Guide**
- **Top 60 Data Book**
- **Military Products Brochure**
- **Sample Kit of Hot Maxim Products**

PLACE
FIRST
CLASS
POSTAGE
HERE

MAXIM
Maxim Integrated Products, Inc.
120 San Gabriel Drive
Sunnyvale, CA 94086

Attention: Seminar Coordinator

Maxim's 1990 Analog Design Seminar Schedule

Maxim's 1990 Analog Design Seminar is being held in major cities across the United States. Choose a location near you and either mail the attached reply card to Maxim, call us at (408) 737-7600, FAX your reservation in at (408) 737-7194, or contact your Maxim representative.

#1	AZ, Phoenix	May 15
#2	AZ, Tucson	May 16
#3	CA, North L.A.	June 13
#4	CA, Orange County	June 27
#5	CA, Sacramento	May 17
#6	CA, San Diego (a.m.)	June 14
#7	CA, San Diego (p.m.)	June 14
#8	CA, San Fernando Valley	June 26
#9	CA, San Gabriel Valley	June 12
#10	CA, San Jose	May 15
#11	CA, San Jose	May 16
#12	CA, San Jose	June 19
#13	CO, Denver (Boulder)	April 17
#14	CT, Waterbury	May 22
#15	FL, Clearwater	May 29
#16	FL, Ft. Lauderdale	June 1
#17	FL, Melbourne	May 31
#18	FL, Orlando	May 30
#19	GA, Atlanta	June 8
#20	IL, Chicago (Rockford)	May 22
#21	IL, Schaumburg	May 22
#22	IN, Indianapolis	June 15
#23	KS, Kansas City	May 30
#24	MA, Boston	June 27
#25	MD, Baltimore	June 5
#26	MI, Detroit (Livonia)	May 10
#27	MI, Grand Rapids	June 6
#28	MN, Minneapolis	June 4
#29	MN, Minneapolis	June 5
#30	Montreal, Quebec	April 23
#31	MO, St. Louis	May 31
#32	NC, Raleigh	June 6
#33	NH, Nashua	June 26
#34	NJ, Fairfield	May 24
#35	NM, Albuquerque	May 17
#36	NM, Las Cruces	May 18
#37	NY, Smithtown, L.I.	May 23
#38	NY, Rochester	April 26
#39	NY, Syracuse	April 27
#40	OH, Cleveland	June 12
#41	OH, Columbus	June 14
#42	OH, Dayton	June 13
#43	OK, Tulsa	May 4
#44	OR, Portland	May 10
#45	Ottawa, Ontario	April 24
#46	PA, Ft. Washington	June 7
#47	TN, Knoxville	June 7
#48	Toronto, Ontario	April 25
#49	TX, Austin	May 3
#50	TX, Dallas	May 1
#51	TX, Ft. Worth	April 30
#52	TX, Houston	May 2
#53	UT, Salt Lake City	April 19
#54	Vancouver, B.C.	May 7
#55	WA, Seattle	May 8
#56	WI, Milwaukee	May 24

Maxim's 1990 Analog Design Seminar Reservation

Select the seminar location nearest to you, noting the seminar number when reserving your seat:

Seminar No.:__________ Location:__________ Date:__________

Name:__________ Job Title:__________

Company:__________ Dept./Div.:__________

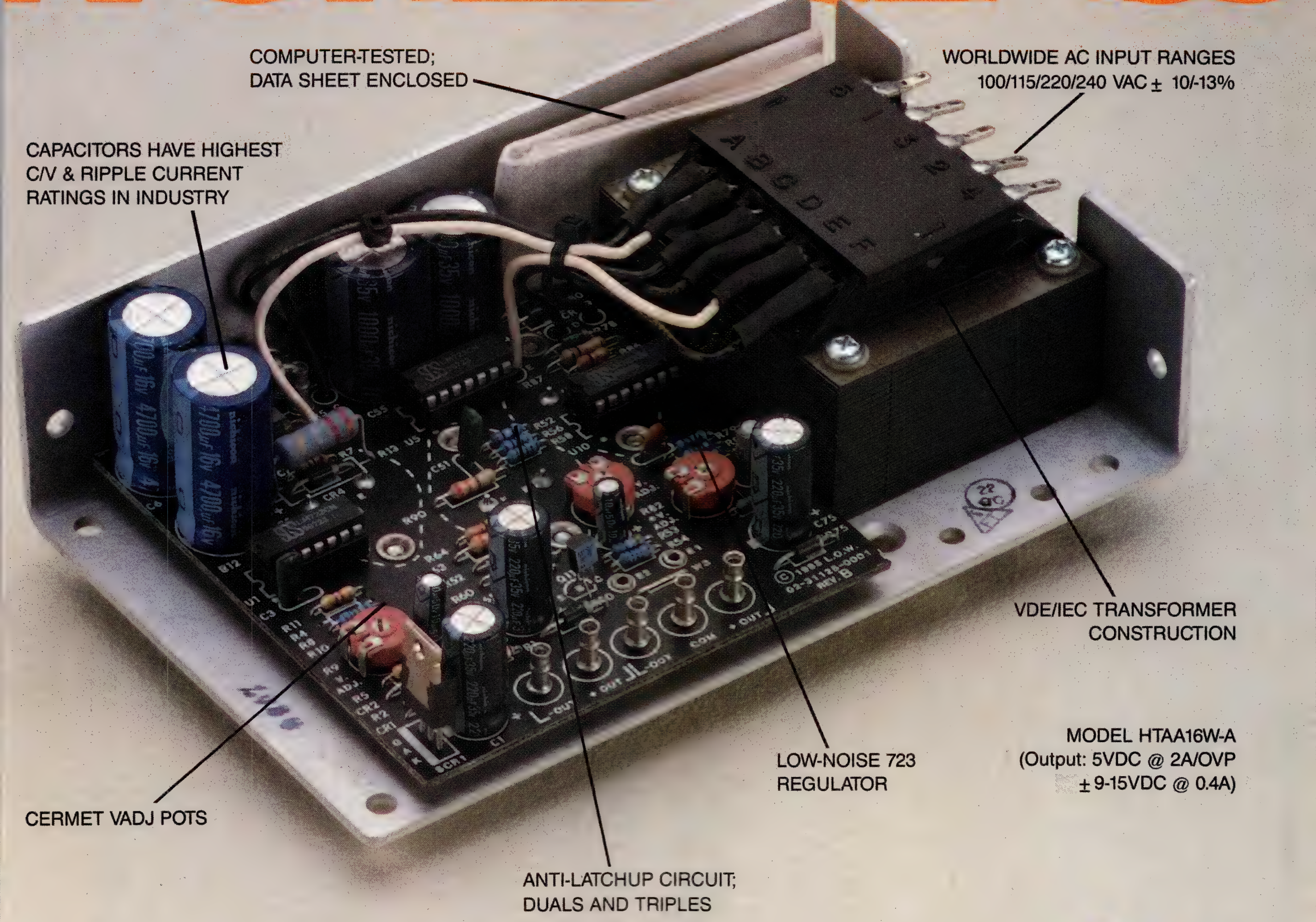
Address:__________

City:__________ State:__________ Zip Code:__________

Please indicate your telephone number below. Maxim's representative will inform you of hotel/location and starting time (most seminars start at 8:30 a.m.): (   ) __________. **Refreshments will be served.**

☐ Sorry, I won't be able to attend. Please send me a set of the Seminar literature.

WORLD CLASS


COMPUTER-TESTED; DATA SHEET ENCLOSED
WORLDWIDE AC INPUT RANGES 100/115/220/240 VAC ± 10/-13%
CAPACITORS HAVE HIGHEST C/V & RIPPLE CURRENT RATINGS IN INDUSTRY
VDE/IEC TRANSFORMER CONSTRUCTION
MODEL HTAA16W-A (Output: 5VDC @ 2A/OVP ± 9-15VDC @ 0.4A)
LOW-NOISE 723 REGULATOR
CERMET VADJ POTS
ANTI-LATCHUP CIRCUIT; DUALS AND TRIPLES

Condor's International linear power supplies — certified to UL544.

Condor's *International Series II* D.C. power supplies virtually eliminate primary-secondary shorting because each coil uses a separate bobbin surrounded by two layers of glass-impregnated plastic, giving complete mechanical and electrical isolation.

The best low-noise 723 regulator chips are used throughout the line, together with proven, reliable semiconductors. TO3-cased pass elements are hermetically sealed, and the latest high-density, high-ripple current rating capacitors from proven, high-quality vendors ensure long life and reliability.

International Series II features:

- 7 power levels — 3 to 150W
- 70 models (single, dual & triple output)
- OVP on all 5V outputs
- Meets EMI per FCC/VDE B (most units)
- Hermetically sealed power transistors
- MTBF 200,000 + hours per Mil Hndbk 217D
- 2-hour burn-in with cycling
- Full 3-year warranty
- 5th-generation design by Tom Ingman — most copied designer in the power supply industry

Sixty-five *International Series II* models are approved to UL478/1012; CSA C22.2 and TUV certified to VDE 0806 and IEC 435, 1 & 2. Twenty-six models are also approved to UL544. Call us today and put Condor's world-class power supplies to work for you!

Send for our free catalog!

250 power supplies!
Switchers and linears!
Open frame and enclosed!
Custom capability!

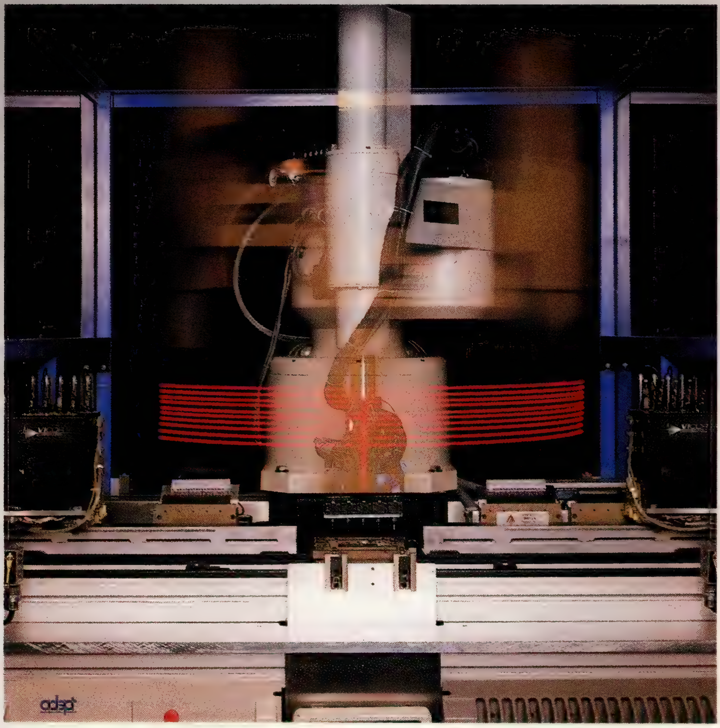
CONDOR INC.
DC POWER SUPPLIES

2311 Statham Parkway, Oxnard, CA 93030
(805) 486-4565 • TWX: 910-333-0681
FAX: (805) 487-8911
CALL TOLL-FREE: 1-800-235-5929 (outside CA)

CIRCLE NO. 33

The Dawn Of The Power Component Industry . . .

"When we first introduced our component-level Megahertz converters we also sowed the seeds of the Power Component Industry . . . the rational alternative to the horror-show of conventional Power Supply development.



Offering repeatable and predictable performance, and exhibiting power density, efficiency, reliability, and "instant expandability" unachievable with conventional power supplies, Power Components revolutionized the power system design process in much the same way that integrated circuits revolutionized circuit design. Since then, our evolving product line of power building blocks has grown to include high power Mega and Master Modules, off-line Front Ends, FlatPACs, StakPaks, and PowerCages: user-definable, single or multiple-output off-line solutions with outputs from 50 to 7200 Watts . . . offering the highest power densities in the industry. Power Systems Architects have enthusiastically embraced the Power Component concept . . . so many, in fact, that nearly half a million of our expanding line of off-the-shelf component-level power products have gone into service worldwide.

"We would like to report to you on our progress in implementing an automation strategy aimed at achieving the highest level of quality and repeatability while minimizing costs and lead times. Our Andover facility is designed for high volume production of Vicor's present families of modular converters . . . while retaining the flexibility to handle tomorrow's . . . with assembly cells incorporating many unique features:

- "Every part, *both passive and active,* is electrically tested just prior to onsertion . . . a reflection of our commitment to zero defects . . .
- "In-line vision systems check solder paste on each pad; orientation of onserted parts; size and fit of pins; and dimensioning of the PC board itself . . . a reflection of our commitment to quality of assembly . . .
- "Fully automatic testers subject every converter to a total of *six* comprehensive in-line tests, including tests at both room and elevated temperatures . . . a reflection of our commitment to total quality control . . .
- "SmartCell software picks and installs trim components for each module after calculating the optimum value based upon *actual measured values* of related parts . . . a reflection of our commitment to "peas-in-a-pod" repeatability . . .
- "*Every* part for *every* converter model is on line at all times, allowing Vicor to "random access" manufacture any mix of product, in lot sizes as small as one, *without impacting throughput and with a cycle time of only four hours.*

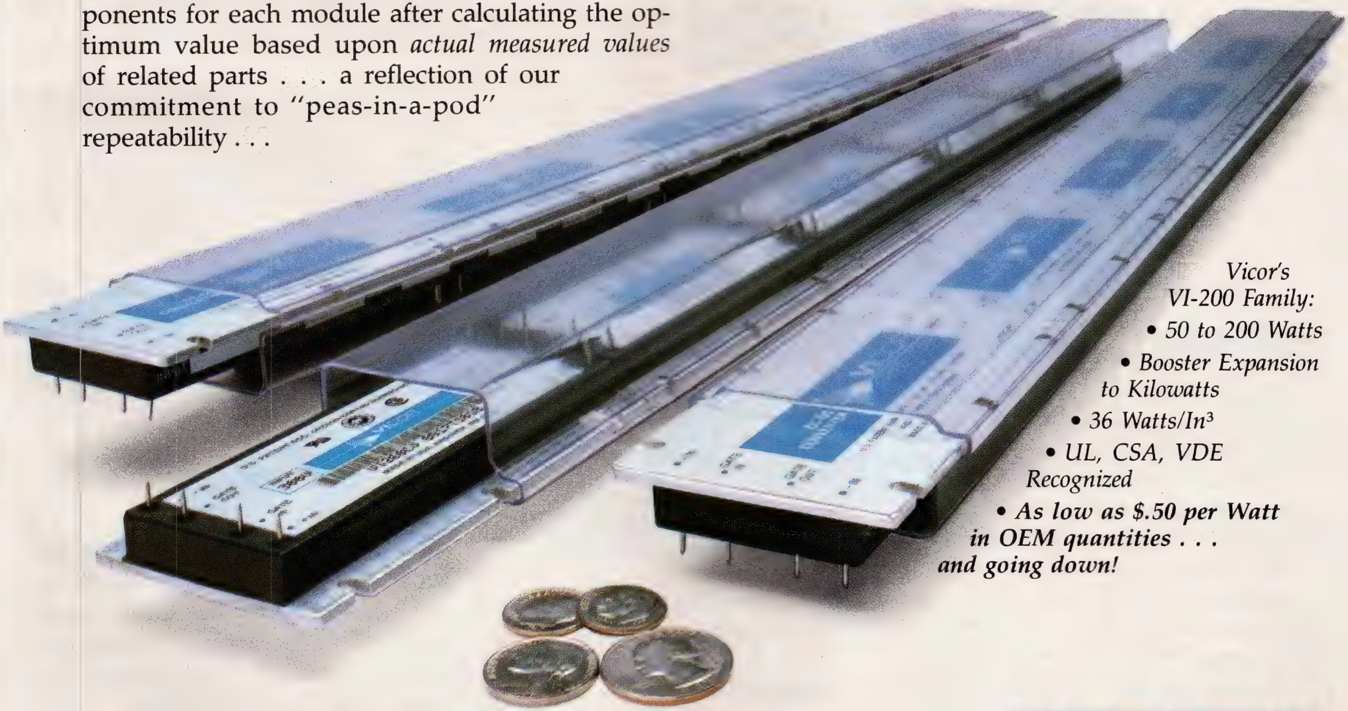
Patrizio Vinciarelli, Ph.D., President/CEO

"As an investment aimed at delivering products of the highest quality at the lowest price, in the shortest time, domestic automation represents Vicor's commitment to World Class Manufacturing as a means of maintaining market leadership through customer satisfaction. With inflexible, bulky, and unpredictable conventional approaches to power systems receding into technological history and with Vicor ready today to supply you with state-of-the-art power products at competitive prices... ***it's time to switch to the Power Component Industry as the sensible source for all your power needs."***

To receive a complete catalog, including information on Vicor Products, Applications and Accessories, call Vicor today at **(800) 735-6200.**

For immediate delivery of Converters, or Power Supplies configured to your needs, ask for

VICOR EXPRESS

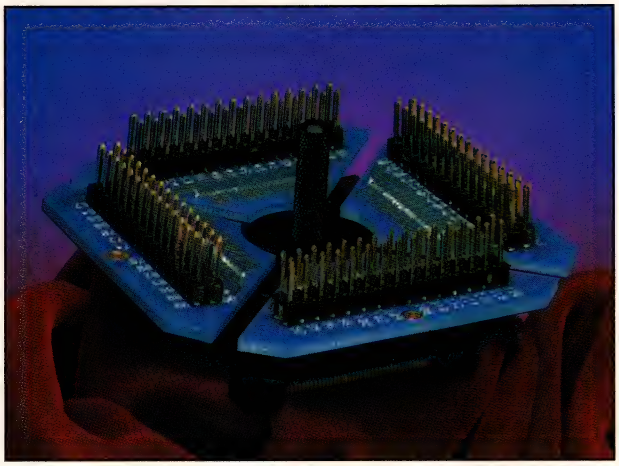


Vicor's VI-200 Family:

- *50 to 200 Watts*
- *Booster Expansion to Kilowatts*
- *36 Watts/In³*
- *UL, CSA, VDE Recognized*
- ***As low as $.50 per Watt in OEM quantities . . . and going down!***

Component Solutions For Your Power System

VICOR



Call your Emulation Technology Distributor:

Australia	61-3-720-3977
Belgium	32-15-212223
Canada	613-725-2177
Denmark	45-44-532-244
England	44-234-266455
Finland	358-0-334133
France	33-1-69412801
Germany	49-89-4602071
Hong Kong	852-3-7173186
India	91-11-6418470
Israel	972-3-561-6925
Italy	39-2-353-8041
Japan	81-3-988-7534
Korea	82-2-558-1144-9
Netherlands	31-10-450-1444
Norway	47-2-900900
Singapore	65-2817244
Spain	34-1-455-8112
Sweden	46-8-744-0300
Switzerland	41-1-723-1241
Taiwan	886-2-721-9533-4

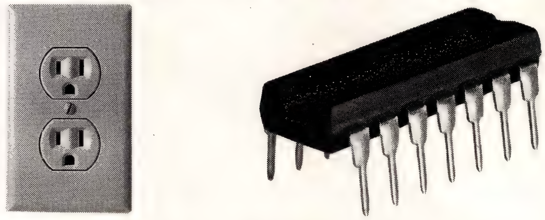
Test Clips for PQFP Devices

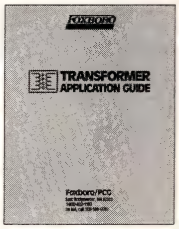
- This is the only way to test your PQFP devices while they're soldered to a PC board!
- PQFP Clips™ piggyback onto a soldered-in PQFP, and convert the leads into standard .1″ test points.
- Can also be used to convert a PQFP to any other IC package type for easy emulation.
- Quick turnaround on custom engineering services, if needed. For a free catalog, contact:

ET

Emulation Technology, Inc.
2344 Walsh Ave. Santa Clara, CA 95051
Phone: 408-982-0660 FAX: 408-982-0664

CIRCLE NO. 3





TO GET FROM HERE TO HERE

You need a really good guide.

And this is it. The only transformer guide available that can help you get from wall plug to semiconductor chip circuit requirements with the least possible trouble.

Common mode inductor. Microprocessor power. DC-to-DC converter. F.E.T. driver. Telephone-interconnect series of transformers—that can be critical to your electronics design. Board level. Total systems.

In short, everything associated with plug-to-chip energy management. And communications signals from "wet circuit" to "dry circuit". Along with the expertise you need to design it right the first time.

Plug into a good thing. Simply write us at East Bridgewater, MA 02333. Or call 1-800-422-1107. In Massachusetts, call (508) 378-5260.

Foxboro/PCG

FOXBORO

CIRCLE NO. 4

CALENDAR

Advances in Semiconductors and Superconductors: Physics Toward Device Application and Exhibit, San Diego, CA. The International Society for Optical Engineering, Box 10, Bellingham, WA 98227. (206) 676-3290. FAX 206-647-1445. March 17 to 21.

Professional Development Seminar, Houston, TX. USENIX Association, 5398 Manhattan Circle, Boulder, CO 80303. (303) 499-2600. FAX 303-499-2608. March 19.

Second Annual Oregon Workshop on Software Metrics, Portland, OR. Warren Harrison, The Oregon Center for Advanced Technology Education, Portland State University, Portland, OR 97207. (503) 725-3108. FAX 503-725-4882. March 19 to 20.

NCGA '90 —Conference and Exposition, Anaheim, CA. NCGA '90, National Computer Graphics Association, 2722 Merrilee Dr, Suite 200, Fairfax, VA 22031. (800) 225-6242; in VA, (703) 698-9600. FAX 703-560-2752. March 19 to 22.

CASE World Conference/Exposition, Los Angeles, CA. Digital Consulting Inc, 6 Windsor St, Andover, MA 01810. (508) 475-6990. March 20 to 22.

Mid-Lantic Electronics Show '90, King of Prussia, PA. Judith Ginsberg, Electronic Representatives Association, Mid-Lantic Chapter, 4113 Barbery Dr, Lafayette Hill, PA 19444. (215) 828-2271. FAX 215-941-6773. March 20 to 22.

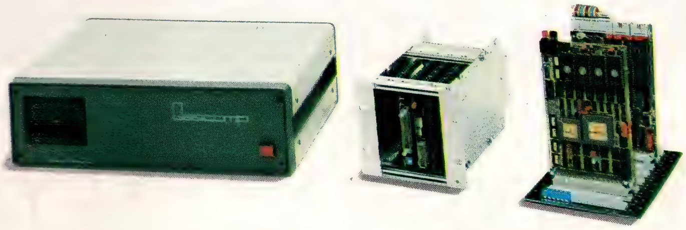
7th International Conference on Technology and Education, Brussels, Belgium. In North, Central, and South America: Mr Jamie Alexander, Radio Shack, Education Div, 1600 One Tandy Center, Fort Worth, TX 76102. (817) 390-3053. In Europe and Asia: Ms Gillian Esplin, CEP Consultants Ltd, 26-

"I can't tell you who I am...

"...or the name of my company. Let me just say that I am the test engineering manager of one of the largest and most successful American manufacturers of automotive electronic products. Our customers include not only "the big three" but also major European and Japanese auto manufacturers. We have been using GESPAC real-time microsystems in our dedicated high speed production testers.

We believe this is giving us an unprecedented edge over our closest competition. In fact, when we show our plant to our Japanese visitors, we carefully cover the GESPAC equipment to protect what we perceive to be one of our most valuable trade secrets." — *Actual customer testimonial.*

GESPAC is the world's leading manufacturer of single height Eurocard board level microsystems and real-time microcomputers for industrial OEM, military and research applications. For free product information, call toll-free 1-800-4-GESPAC or (602) 962-5559.



Discover GESPAC before your competition does.

Gespac

USA - CANADA
50 West Hoover Ave.
Mesa, Arizona
85210 USA
Tel. (602) 962-5559
Fax. (602) 962-5750

EUROPE
Z.I. les Playes
83500 La Seyne
France
Tel. 94 30 34 34
Fax. 94 87 35 52

INTERNATIONAL
18, Chemin des Aulx
CH-1228 Geneva
Switzerland
Tel. (022) 794 3400
Fax. (022) 794 6477

CIRCLE NO. 35

THE ONLY ONE on CD-ROM

SPECMASTER

50,000 DOD-Listed Mil-Specs, Standards, Handbooks., etc. Full Text with Drawings!

Available with National Aerospace Standards and SAE Standards.

- Military and federal standards and specifications including handbooks, MS drawings, QPLs, DIDs and CIDs.
- Plus thousands of vendor catalogs including top defense contractors.
- Specmaster is updated monthly.
- Now you can search, retrieve, review and print standards and specs with computer speed and ease.
- Works with an IBM AT or compatible 286 personal computer with DOS 3.1 or later.

Call 800-638-8094
for a demonstration or more information. In MD 301-590-2300.

National Standards Association

1200 Quince Orchard Boulevard ☐ Gaithersburg, MD 20878

CIRCLE NO. 5

DID YOU KNOW?

EDN serves
electronic engineers and
engineering managers in more than
100 countries worldwide.

EDN

CALENDAR

28 Albany St, Edinburgh, EH 1 3QH, UK. (031) 557-5749. March 20 to 22.

IBM Automation Workshop, Blacksburg, VA. Dr Linda Leffel, Donaldson Brown Center for Continuing Education, Virginia Tech, Blacksburg, VA 24061. (703) 231-4848. March 22 to 24.

Designing for Electromagnetic Compatibility (short course), Boston, MA. Hewlett-Packard Co, Signal Analysis Div, 1212 Valley House Dr, Rohnert Park, CA 94928. (508)794-2713. March 26 to 27.

Flat Panel Displays—New Technology Developments and Emerging End-Use Applications, Boston, MA. Frost & Sullivan Inc, 106 Fulton St, New York, NY 10028. (212) 233-1080. FAX 212-619-0831. March 26 to 27.

Image Scanning and Processing: Technologies and Applications, Miami, FL. Kathy Greeley, BIS CAP International Research Publications & Conferences Div, Box 68, Newtonville, MA 02160. (617) 893-9130. FAX 617-894-5093. March 26 to 28.

CARTS 90, Capacitor and Resistor Technology Symposium, San Francisco, CA. Components Technology Institute Inc, 904 Bob Wallace Ave, Suite 117, Huntsville, AL 35801. (205) 536-1304. March 26 to 29.

1990 12th International Conference on Software Engineering, Nice, France. IEEE Computer Society, Conference Services, 1730 Massachusetts Ave NW, Washington, DC 20036. (202) 371-1013. March 26 to 30.

HEWLETT PACKARD® & Tektronix®

DIGITAL SCOPES/LOGIC ANALYZERS CAN'T DO THIS!

▪ Only ORION delivers next-generation high performance integrated digital scope-logic analyzer with . . .

▪ Precisely time-aligned analog and digital traces.

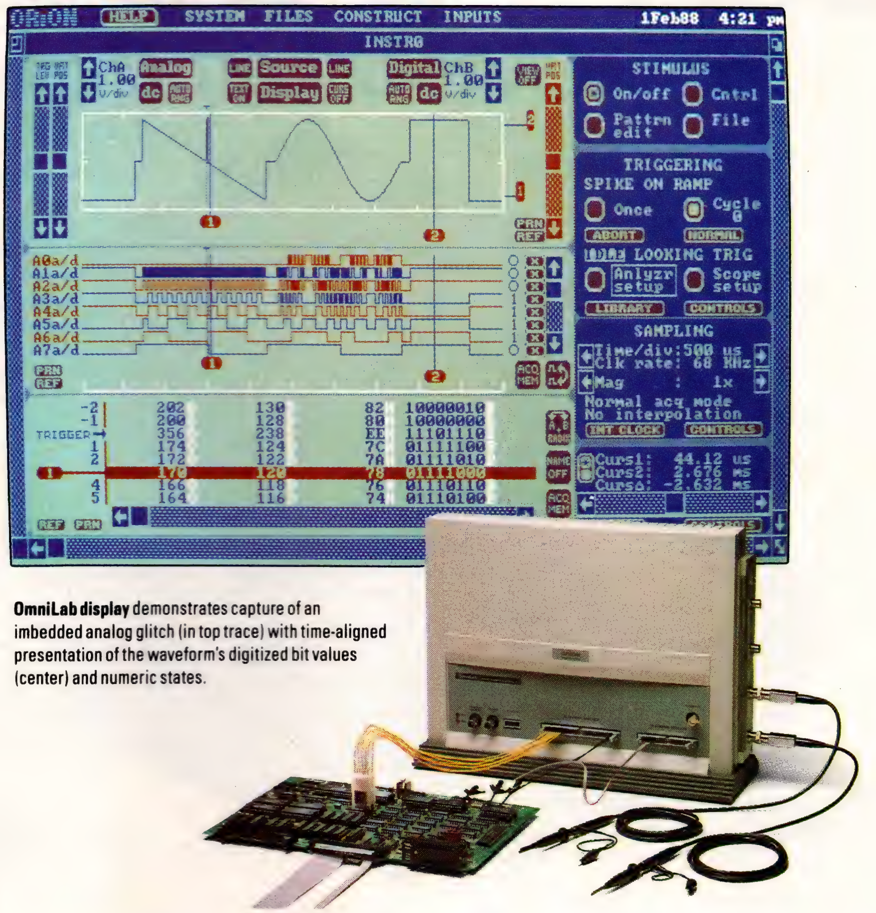
Our 9240 is a whole new class of instrument that vastly simplifies development. It lets you watch time-correlated digital and analog signals from the same circuit—on the same screen at the same time. And with nano-second correlation.

▪ SELECT™ triggering for swift sure capture of rare events.

SELECT triggering bridges the gap between scope and analyzer techniques. So you can simultaneously trigger on digital and analog signal abnormalities. With the 9240's deep trace buffer you can scroll back and forth in time, observing fault-causing conditions, and after effects.

▪ Customizable instrument configurations.

The 9240's general-purpose hardware allows you to configure and implement numerous application-specific instruments on the screen of your AT or PS/2, via simple pull-down menus. Then save the setups for future use. It's like having a benchtop of instruments in one.



```
       -2 |   202   130   82  10000010
       -1 |   200   128   80  10000000
TRIGGER-> |   356   238   EE  11101110
        1 |   174   124   7C  01111100
        2 |   172   122   7A  01111010
        1 |   170   120   78  01111000
        4 |   166   118   76  01110110
        5 |   164   116   74  01110100
```

```
Time/div:500 us
Clk rate: 68 KHz
Mag     :  1x
Normal acq mode
No interpolation
```

```
Curs1:   44.12 us
Curs2:   2.676 ms
CursΔ:  -2.632 ms
```

OmniLab display demonstrates capture of an imbedded analog glitch (in top trace) with time-aligned presentation of the waveform's digitized bit values (center) and numeric states.

▪ And with the 9240, you can troubleshoot in fewer steps than ever before—without compromising high performance specs. Result: you'll pinpoint faults faster and easier, get your designs to market quicker.

For more information, call toll free **800/729-7700**
Or write for complete literature.

▪ Available for rent from U.S. Instrument Rentals, Inc., 800/824-2873

NO-COMPROMISE 9240 SPECIFICATIONS

DIGITAL OSCILLOSCOPE		LOGIC ANALYZER	
Digitizers:	Two, 8 bit	Inputs:	48, timing and state
Bandwidth:	100 MHz	Asynchronous Clocking:	34 MS/s on 48 inputs; 204 MS/s on 8 inputs
Single-Shot Digitizing:	34 S/s to 204 MS/s	Repetitive Sampling:	680 MS/s on 48 inputs
Repetitive Sampling:	680 MS/s	Synchronous Clocking:	0 to 34 MS/s
Scale Factor:	10 mV/div to 10V/div in 1-2-5 sequence	Acquisition Memory:	4K samples (16K optional)
Record Length:	4K (16K optional)	Disassembly Options:	Over 33 microprocessors
ANALOG STIMULUS		**DIGITAL STIMULUS**	
Output:	8mV to 8 V peak-to-peak, 8 bit	Outputs:	24, 74F tri-state drivers
Cycle Length:	4 to 4K samples (16K optional)	Cycle Length:	4 to 4K samples (16K optional)
Clocking:	34 S/s to 34 MS/s	Timing:	34S/s to 34MS/s
Functions:	Record, edit and playback	Functions:	Record, edit and playback

Free Literature Available

ORION
INSTRUMENTS
180 Independence Drive
Menlo Park, California 94025
TELEPHONE: 415/327-8800
FAX: 415/327-9881

Computer Integrated Instrumentation

*SELECT triggering is a trademark of Orion Instrument, Inc.
Hewlett Packard is a trademark of Hewlett Packard Company.
Tektronix is a trademark of Tektronix, Inc.

CIRCLE NO. 36

RF TRANS

Over 50 off-the-shelf models...

Having difficulty locating RF or pulse transformers with low droop, fast risetime or a particular impedance ratio over a specific frequency range?...Mini-Circuits offers a solution.

Choose impedance ratios from 1:1 to 36:1, connector or pin versions (plastic or metal case built to meet MIL-T-21038 and MIL-T-55831 requirements*). Ultra-wideband response achieves low droop and fast risetime for pulse applications. Ratings up to 1000M ohms insulation resistance and up to 1000V dielectric voltage. For wide dynamic range applications involving up to 100 mA DC primary current, use the T-H series. Coaxial connector models are offered with 50 and 75 ohm impedance; BNC standard; request other types. Available for immediate delivery with one-year guarantee.

Call or write for 68-page catalog or see our catalog in EEM, or Microwaves Product Data Directory.

*units are not QPL listed

case styles
T, TH, case W 38, X 65 bent lead version, KK81 bent lead version
TMO, case A 11, † case B 13 FT, FTB, case H 16
NEW TC SURFACE MOUNT MODELS from 1MHz to 1500 MHz

NSN GUIDE

MCL NO.	NSN	MCL NO.	NSN
FTB1-1-75	5950-01-132-8034	TMO2-1	5950-01-183-6414
FTB1-6	5950-01-225-8773	TMO2.5-6	5950-01-215-4038
T1-1	5950-10-128-3745	TMO2.5-6T	5950-01-215-8697
T1-1T	5950-01-153-0668	TMO3-1T	5950-01-168-7512
T2-1	5950-01-106-1218	TMO4-1	5950-01-067-1012
T3-1T	5950-01-153-0298	TMO4-2	5950-01-091-3553
T4-1	5950-01-024-7626	TMO4-6	5950-01-132-8102
T9-1	5950-01-105-8153	TMO5-1T	5950-01-183-0779
T16-1	5950-01-094-7439	TMO9-1	5950-01-141-0174
TMO1-1	5950-01-178-2612	TMO16-1	5950-01-138-4593

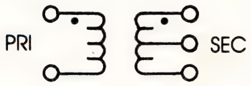
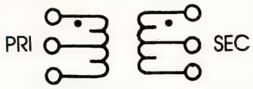
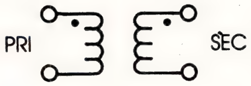
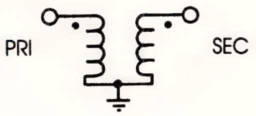
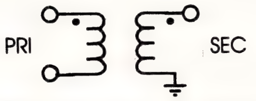
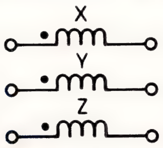
finding new ways ...
setting higher standards

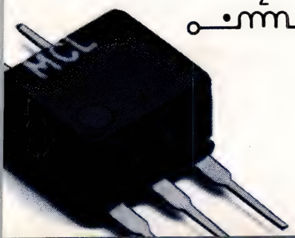
Mini-Circuits
A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

C72-1 REV. B

FORMERS

3KHz-800MHz from $\$3^{25}$

case style number see opposite page		MODEL NO.	Ω RATIO	FREQUENCY MHz	INSERTION LOSS			PRICE $
					3dB MHz	2dB MHz	1dB MHz	Qty. (1-9)
A* 	T	T1-1T	1	.05-200	.05-200	.08-150	.2-80	4.45
		T1-6T	1	.003-300	.003-300	.01-150	.02-50	6.95
		T2-1T	2	.07-200	.07-200	.1-100	.5-50	4.95
		T2.5-6T	2.5	.01-100	.01-100	.02-50	.50-20	4.95
		T3-1T	3	.05-250	.05-200	.1-200	.5-70	4.95
		T4-1	4	.2-350	.2-350	.35-300	2-100	3.25
		T4-6T	4	.02-250	.02-250	.05-150	0.1-100	4.45
		T5-1T	5	.3-300	.3-300	.6-200	.5-100	4.95
		T8-1T	8	.03-140	.03-140	.10-90	1-60	7.95
		T13-1T	13	.3-120	.3-120	.7-80	5-20	4.95
		T16-6T	16	.03-75	.03-75	.06-30	.1-20	5.65
	TH	T4-1H	4	10-350	10-350	15-300	25-200	5.95
	TMO	TMO1-1T	1	05-200	.05-200	.08-150	.2-80	7.95
		TMO2-1T	2	.07-200	.07-200	.1-100	.5-50	8.45
		†TMO2.5-6T	2.5	.01-100	.01-100	.02-50	.05-20	8.45
		†TMO3-1T	3	.05-250	.05-250	.1-200	.5-70	7.95
		TMO4-1	4	.2-350	.2-350	.35-300	2-100	6.25
		TMO5-1T	5	.3-300	.3-300	.6-200	5-100	8.45
		TMO13-1T	13	.3-120	.3-120	.7-80	5-20	8.45
B* 	TT	TT1-6	1	.004-500	.004-500	.02-200	.1-50	6.95
		TT1.5-1	1.5	.075-500	.075-500	.2-100	1-50	5.95
		TT2.5-6	2.5	.01-50	.01-50	.025-25	.05-10	6.45
		TT4-1	3	.05-200	.2-50	.2-50	1-30	5.95
		TT4-1A	4	0.1-300	0.1-300	0.2-250	0.3-180	6.95
		TT25-1	25	.02-30	.02-30	.05-20	.1-10	9.95
	TTMO	TTMO25-1	25	.02-30	.02-30	.05-20	.1-10	11.95
		TTMO1-1	1	.005-100	.005-100	.01-75	.05-40	11.45
		TTMO4-1A	4	0.1-300	0.1-300	0.2-250	0.3-180	13.95
C 	T	T1-1	1	.15-400	.15-400	.35-200	2-50	3.25
		T1.18-3	1.18	0.01-250	0.01-250	0.02-200	0.03-50	5.65
		T1-6	1	.01-150	.01-150	.02-100	.05-50	5.65
		T1.5-1	1.5	.1-300	.1-300	.2-150	.5-80	4.45
		T1.5-6	1.5	.02-100	.02-100	.05-50	0.1-25	5.65
		T2.5-6	2.5	.01-100	.01-100	.02-50	.05-20	4.45
		T4-6	4	.02-200	.02-200	.05-150	.1-100	4.45
		T9-1	9	.15-200	.15-200	.3-150	2-40	3.95
		T16-1	16	.3-120	.3-120	.7-80	5-20	4.45
		T36-1	36	.03-20	.03-20	.05-10	.1-5	6.95
	TO	TO-75	1	10-500	—	10-500	40-250	6.95
	TH	T1-1H	1	8-300	8-300	10-200	25-100	5.95
		T9-1H	9	2-90	2-90	3-75	6-50	6.45
		T16-H	16	7-85	7-85	10-65	15-40	6.45
	TMO	TMO1-02	1	1-800	1-800	2-500	—	9.45
		TMO1-1	1	.15-400	.15-400	.35-200	2-50	6.25
		TMO1.5-1	1.5	.1-300	.1-300	.2-150	.5-8	8.45
		†TMO2.5-6	2.5	.01-100	.01-100	.02-50	.05-20	7.95
		†TMO4-6	4	.02-200	.02-200	.05-150	.1-100	7.95
		TMO6-1	6	.3-200	.3-200	.5-150	5-50	7.95
		TMO9-1	9	.15-200	.15-200	.3-150	2-40	7.95
		TMO16-1	16	.3-120	.3-120	.7-80	5-20	7.95
D 	T	T2-1	2	.050-600	.050-600	.1-400	.5-200	3.95
		T3-1	3	.5-800	.5-800	2-400	—	4.45
		T4-2	4	.2-600	.2-600	.5-500	2-250	3.95
		T8-1	8	.15-250	.15-250	.25-200	2-100	3.95
		T14-1	14	.2-150	.2-150	.5-100	2-50	4.95
	TMO	TMO2-1	2	.050-600	.050-600	.1-400	.5-200	7.95
		TMO3-1	3	.5-800	.5-800	2-400	—	8.45
		TMO4-2	4	.2-600	.2-600	.5-500	2-250	7.95
		TMO8-1	8	.15-250	.15-250	.25-200	2-100	7.95
		TMO14-1	14	.2-150	.2-150	.5-100	2-50	8.45
	FT	FT1.22-1	1.22	.005-100	.005-100	.01-50	.05-25	35.95
		FT1.5-1	1.5	.1-400	.1-400	5-200	1-100	35.95
E 	FTB	FTB-1	1	.2-500	.2-500	.5-300	1-100	36.95
		FTB1-6	1	.01-125	.01-125	.05-50	.1-25	36.95
		■FTB-1-75	1	.5-500	.5-500	5-300	10-100	36.95
F 	T	T-622	1	0.1-200	0.1-200	0.5-100	5-80	3.25
		T626	1	0.01-10	0.01-10	0.2-5	.04-2	3.95



■ Denotes 75 ohm models

* FOR A AND B CONFIGURATIONS
Maximum Amplitude Unbalance
0.1 dB over 1 dB frequency range
0.5 dB over entire frequency range

Maximum Phase Unbalance
1.0° over 1 dB frequency range
5.0° over entire frequency range

CIRCLE NO. 37

Communication solutions from Rockwell.

The assignment was demanding. The integral modem for the company's new Laptop would have to be compact and inexpensive. With the complete '88 AT command set, plus the lowest possible power consumption.

"The features they packed into the world's first single-device V.22bis modem blew us away."

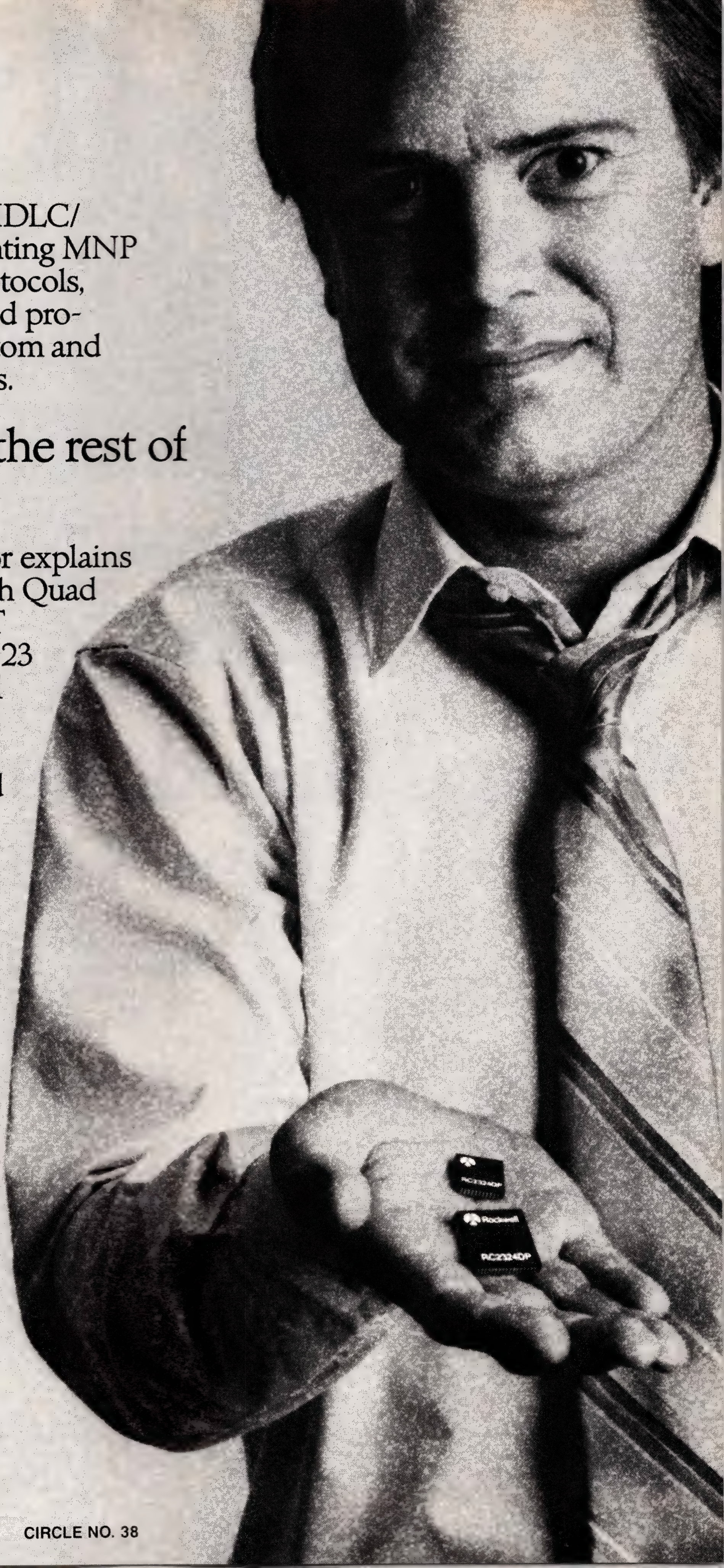
Fortunately, the engineers already know who to call: Rockwell International. They're aware that no matter what the application, Rockwell's new V.22bis family provides capabilities nobody else can supply.

They've read how Rockwell stunned the industry with its RC224AT—the world's first fully integrated single-device modem solution. And how this one compact component offers CCITT V.22bis and V.22, as well as Bell 212A and 103 compliance, plus value-added features such as power-saving Automatic Sleep Mode. Not to mention the assurance of a five-year warranty.

Their call to Rockwell also reveals how the V.22bis family can help with future projects. They learn about the capabilities of Rockwell's RC2324DP chip set.

They hear how it provides HDLC/SDLC framing for implementing MNP 5™, X.25, LAPM and V.42 protocols, while offering unprecedented programming flexibility for custom and country-specific applications.

"And then we met the rest of the family."



A Rockwell technical advisor explains that it's the only chip set with Quad capability that meets CCITT V.22bis, V.22A/B, V.21 and V.23 requirements, as well as Bell 212A and 103 standards. He adds that the RC2324SME offers capabilities optimized for Europe, including MNP 5™ and V.25bis.

In no time, the Laptop project is ready for production. To management, the results—as well as the engineers responsible—couldn't look better.

Call the leader in modem technology. Rockwell *is* solutions.

Rockwell International

...where science gets down to business

Aerospace/Electronics/Automotive
General Industries/A-B Industrial Automation

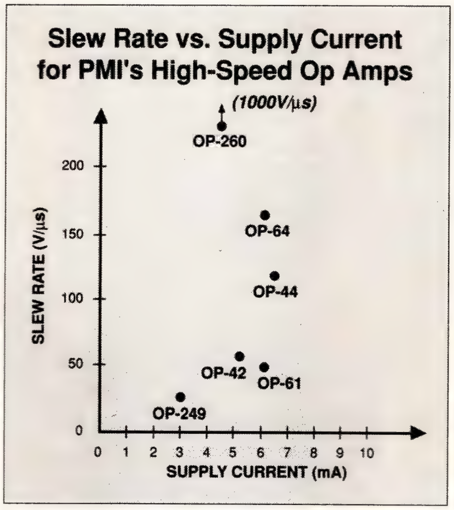
Semiconductor Products Division
Rockwell International
P.O. Box C, M.S. 501-300
Newport Beach, CA 92658-8902
(800) 854-8099
In California, (800) 422-4230

CIRCLE NO. 38

High Speed. Low Power. Low Cost.

Impossible? Not anymore. Today, you can get high-speed operational amplifiers so advanced, they don't rob your system of power. And, better yet, PMI brings you this outstanding performance without holding you up on cost! **For example, PMI's dual OP-260 in an 8-pin mini-DIP package offers a slew rate of 1000V/µs at the low cost of $7.95.**

Plus, we make it easy for you to design with our high-speed op amps.



Slew Rate vs. Supply Current for PMI's High-Speed Op Amps

PMI has developed "PMISpice, advanced SPICE models including J-FET, Bipolar, even current feedback devices. At last, accurate AC modelling!

At PMI we've beat the trade-of between high speed and low power – at affordable prices! Circle the reader service number below to receive complete information on PMI's extensive family of high-speed op amps and advanced SPICE models. In a hurry?
Call us at 800-843-1515.
Or, FAX us at (408) 727-1550.

PMI®

Precision Monolithics Inc.
1500 Space Park Drive
Santa Clara, California 95054-3434

CIRCLE NO. 39

ALTAMONTE SPRINGS: (407) 831-8233, **ATLANTA**: (404) 263-7995, **BOSTON**: (508) 794-0026, **CHICAGO**: (312) 250-0808, **DALLAS**: (214) 690-3495, **DENVER**: (303) 792-9595, **DETROIT**: (313) 930-2051, **LOS ANGELES**: (818) 886-6881, **MILPITAS**: (408) 263-9366, **ORANGE COUNTY**: (714) 637-9602, **PHILADELPHIA**: (215) 953-1070

EDITORIAL

Electricity still kills

Most people coexist with electricity and harness it for their benefit. To them, the electric current that courses through their homes and offices and overhead on light poles is benign. However, research reported in *Electronics World + Wireless World* may change how we think about electricity. An article quotes numerous research reports linking low-frequency electric fields to cancer. Here are a few of the results reported in *EW + WW*'s February 1990 issue:

- You have a 2.6 times greater risk of dying of myeloid leukemia if you work in an electrical profession—particularly if you're a telecommunications engineer or amateur radio operator.
- As many as 10 to 15% of childhood cancer cases may be traced to proximity to power-line fields found in homes. The incidence of cancer more than doubles in households in which the average magnetic-field strength is above 200 nT (nanoteslas).
- More miscarriages are reported by women who use electric blankets or heated water beds during the winter.

These results aren't wild claims. They arose from research done over the past 16 years and are supported by independent work in the USA, United Kingdom, and USSR. Some people have questioned the results and say that secondary effects such as exposure to associated on-the-job carcinogens could have triggered the cancers. However, additional studies have refuted some criticisms. For example, in a study of radio amateurs, higher rates of leukemia were found both for those with and without exposure to on-the-job risks.

In general, fields from external wiring, not household wiring and appliances, were found to cause the biological effects. Overhead high-voltage and power-distribution wiring seem to be the main culprits—along with radio-frequency and microwave radiation. But if your home isn't near a large power line, don't be complacent. Investigations also correlate proximity to the high-voltage step-down transformers in residential areas to an increase in childhood leukemia.

Clearly, it's time to carefully examine our standards for exposure to electromagnetic radiation in the extremely low-frequency (ELF) portion of the spectrum. Some people are taking action. Seven states now have standards that set minimum distances between residences and high-voltage transmission lines. One of these states is Florida, which set a limit of 15 μT along a 230-kV power-line right of way. But a biologically acceptable limit may be much lower. You may believe or you may question the research that *EW + WW* reports, but we think it's time for a major long-range study of the biological effects of power-distribution systems. Then, if it's necessary, we may have to develop new power-distribution systems that limit exposure to ELF electromagnetic radiation.

Jon Titus

Jon Titus
Editor

Jesse H Neal
Editorial Achievement Awards
1987, 1981 (2), 1978 (2),
1977, 1976, 1975

American Society of
Business Press Editors Award
1988, 1983, 1981

Now, One Name Gets You Thousands Of Choices In Components And Materials.

Philips Components Discrete Products Division

The products of Amperex, Mepco/Centralab, and Ferroxcube are now available from one source — Philips Components.

The names have changed, but the industry leadership hasn't.

We still offer superior product quality and performance. On time delivery. Professional service. And competitive prices.

But now it's all backed by one of the world's largest electronic components manufacturers, N.V. Philips. With worldwide resources. You'll benefit from our leadership across all our product groups. And you'll move ahead because of our innovations in surface mount technology.

In Passives: aluminum electrolytic, ceramic, film, variable, and tantalum capacitors. Resistor products include: fixed resistors, varistors, thermistors, sensors, and cermet trimmers. And we're the only tantalum capacitor manufacturer to be certified a Class "A" MRP II user.

In Discrete Semiconductors: vast

Philips Components

selections of small signal products, power devices, and optoelectronic products.

In Professional Components: camera tubes, CCD image sensors, UHF Klystrons, and much more.

In Materials: a broad range of ferrite cores for power supply and telecommunications equipment (pots, U E and I cores, and toroids). Plus beads, chokes and rods for EMI/RFI suppression.

For all this and more, call or write to the broad range product source for solutions: Philips Components Discrete Products Division.

Philips Components
Discrete Products Division
A North American Philips Company
2001 W. Blue Heron Boulevard
P.O. Box 10330
Riviera Beach, FL 33404

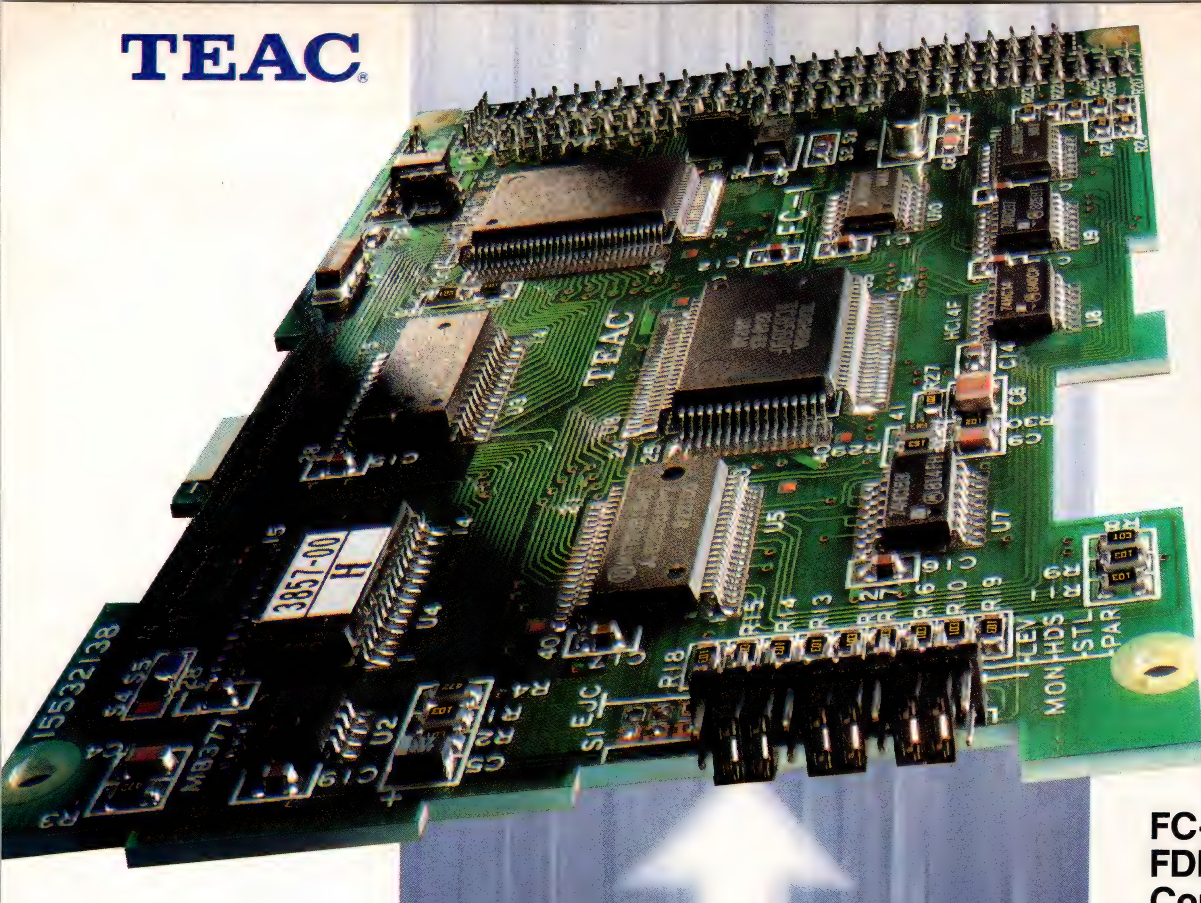
1-800-447-3762
Fax: 407-881-3300

More Products. More Solutions.

PHILIPS

CIRCLE NO. 40

TEAC



FC-1
FDD SCSI Interface Controller

The FC-1: A Fast and Flexible SCSI FDD Controller

The Easy Way to Make Your Floppy Disk Drives Intelligent

An FC-1, small enough to fit inside a 3.5″ FDD, has the intelligence to handle device-independent control of 3.5 and 5¼″ FDDs for the host computer. At its best with 4MB perpendicular recording method drives like the TEAC FD-235J, and equally happy with formats down to 0.5MB, it is compact, lightweight, and competitively priced. Also offering expansibility and reduced host loads, the FC-1 is ideal for the widest possible range of applications.

TEAC FDDs with built-in FC-1 SCSI controllers, including the FD-235HS and FD-235JS, are also available.

CIRCLE NO. 42

FD-235J
3.5″ Micro Floppy Disk Drive

TEAC CORPORATION 3-7-3 NAKA-CHO, MUSASHINO, TOKYO, JAPAN TEL: (0422)52-5041 TLX: 2822451 FAX: (0422)55-2554

■**Hong Kong,** Nissei Sangyo Co., Ltd. Hong Kong Branch Tel: 3-343441-6; KARIN ELECTRONIC SUPPLIES CO., LTD. Tel: 3-898252 ■**Singapore,** NISSEI ELECTRONICS, LTD. SINGAPORE BRANCH OFFICE Tel: 2357900; UAC SINGAPORE REP. OFFICE Tel: 2922608 ■**New Zealand,** DATAMATIC NETWORKS LIMITED Tel: 09-444-0760 ■**Australia,** AWA DISTRIBUTION Tel: 02-888-9000 ■**Indonesia,** CHUGAI BOYEKI CO., LTD. Tel: 370824 ■**Philippines,** COMPEX INTERNATIONAL INC. Tel: 213020 ■**India,** Priya Electronics & Chemicals Limited Tel: 2863611 ■**Kuwait,** Bader Al Mulla & Brothers Co. W.L.L. Tel: 2423250 ■**United Kingdom,** TEKDATA LIMITED Tel: 0782 577677; Data Peripherals (UK) Limited Tel: 0785 57050 ■**F.R. Germany,** nbn Elektronik GmbH Tel: 08152/390 ■**Austria,** nbn Elektronik GmbH Tel: 0316/40 28 05 ■**Netherlands,** SIMAC DATA B.V. Tel: 040-582933 ■**Belgium & Luxemburg,** SIMAC ELECTRONICS SPRL/BVBA Tel: 02/252.36.90 ■**France,** TEKELEC AIRTRONIC S.A. Tel: (1)4534-75-35 ■**Italy,** A.E.S.S.E. S.p.A. Tel: 02/54.64.741 ■**Spain,** ATAIO INSTRUMENTOS S.A. Tel: 733 05 62 ■**Portugal,** BASF PORTUGUESA LDA. Tel: (351) 1-562511 ■**Switzerland,** WENGER PERIPHERALS AG Tel: 01/830 75 55 ■**Denmark,** Dansk Binær Teknik A/S Tel: 03/66 20 20 ■**Sweden,** MACROTEC AB Tel: 08-733 02 20 ■**Norway,** SCANTELE A/S Tel: (02)65 69 20 ■**Finland,** INSTRUMENTARIUM CORPORATION Tel: 90-528 4338

**If no distributor listed above is in your area, please contact us directly for further details about our products.*

MATHEMATICAL SOFTWARE PACKAGES

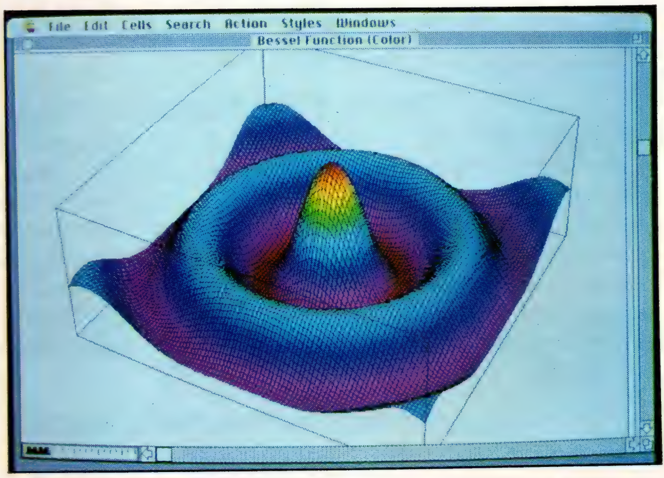
Taking the drudgery out of problem solving

Mathematical software packages let you savor the symbiosis that develops when you immerse yourself in the real problem and leave the number crunching to the computer.

Dan Strassberg,
Associate Editor

General-purpose mathematical applications packages for IBM PC-compatible and Apple Macintosh computers fill an unusual place in the technical software market. Although several of the products include their own programming languages, these packages are primarily for people who have complex problems to solve but who *don't* want to become programmers. Nevertheless, if your only interest is in plugging in numbers and getting answers as painlessly as possible, don't use this kind of software. Sharply focused packages for such purposes as filter synthesis and transformer design are better choices.

General-purpose math applications are for engineers who want to spend their time understanding the problems they are working on and who want to take advantage of the synergy that can exist between humans and computers. By letting your computer do what it does best, these programs free you of the drudgery of manipulating numbers and equations. The software lets you devote your time to tasks that people do best—recognizing nontrivial problems, conceptualizing solutions, and handling special situations (see **box**, "Math software helps consultant get answers fast").



On a color-equipped computer, *Mathematica produces strikingly beautiful graphics, for example this 3-dimensional plot of a Bessel function. But competitors whose software can only produce monochrome graphics question how useful the color really is.*

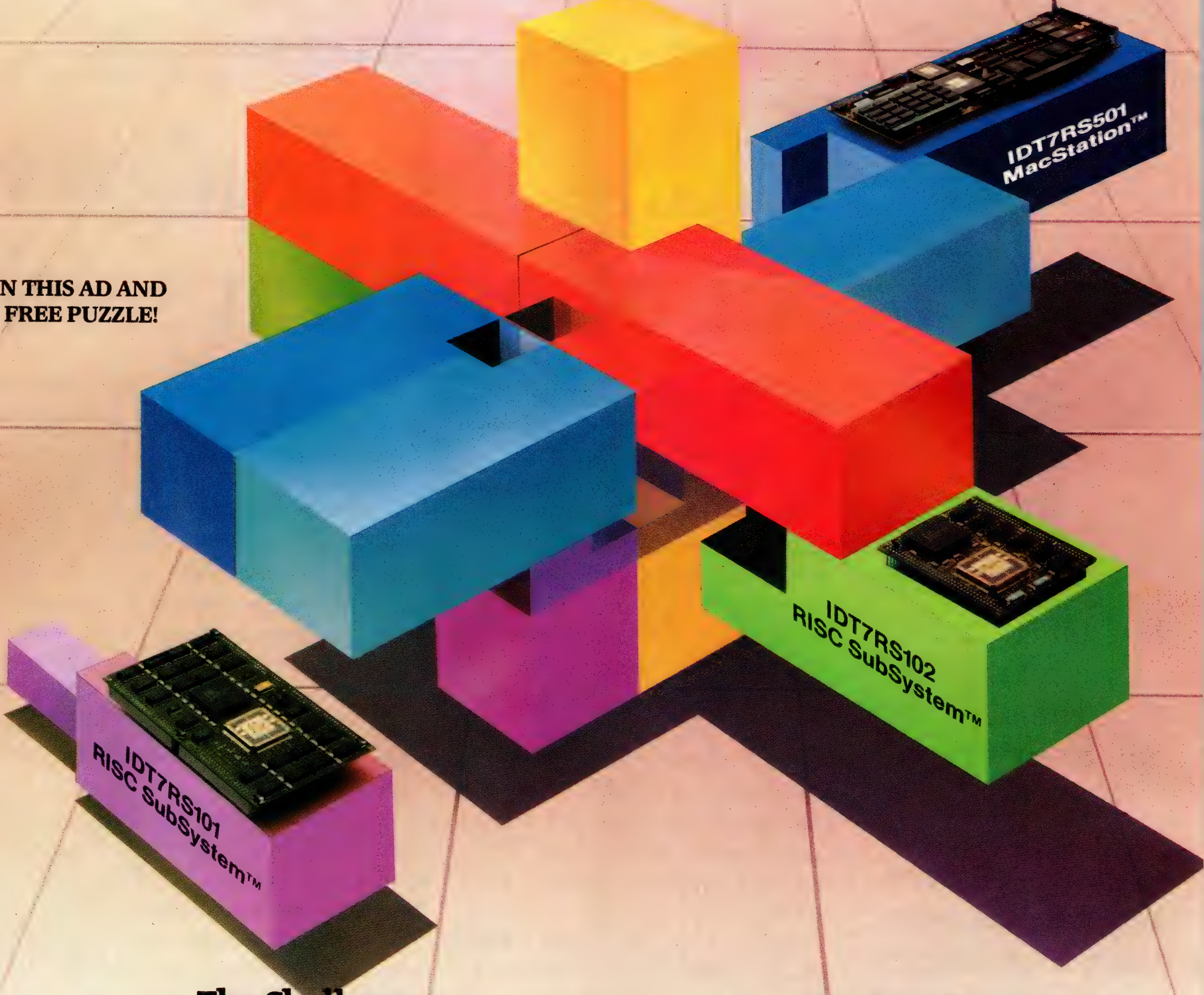
These programs exhibit more diversity than do most products EDN covers in a single article. Their user interfaces differ significantly; their hardware requirements vary; and most of all, though they perform many of the same tasks, each one truly excels at only a small subset of the jobs you can use it for. So, although the programs appear to compete with one another, in a very real sense, many of them are complementary. You may well find that you should have several of them on your shelf. **Table 1** summarizes a few of the major characteristics of the programs.

Mainly, these packages solve algebraic and differential equations, manipulate matrices, perform statistical calculations, and present results in numeric—and in some cases, symbolic—form. Most also display results as 2- and 3-dimensional plots on the computer screen and produce hard copy on plotters and on graphics-capable dot-matrix

The Total Solution

IDT's RISC SubSystem™ Module

SEND IN THIS AD AND GET A FREE PUZZLE!



The Challenge

You want the benefits of RISC CPU performance accelerated by the world's best cache memory with a simple system bus interface—*and* the solution has to work the first time. IDT accepts the challenge by introducing the world's first R3000 RISC SubSystem module, part of IDT's "Building Blocks for the '90s".

Putting the Pieces in Place

The IDT7RS101 RISC SubSystem module integrates IDT's R3000 RISC CPU with the R3010 Floating Point Accelerator, cache memories, and FCT logic into a complete, debugged CPU engine. Implemented on a high-density, surface mounted, 8-layer board, our RISC SubSystem module solves high-speed local bus timing, control, and line length issues while providing the flexibility to tailor clock frequency and system I/O to your specific application. In addition, the IDT7RS301 Development Board provides a generic system board environment for both hardware and software evaluation.

Completing the Puzzle in Record Time

The IDT7RS101, like all of our subsystems, meets your increasing performance demands by incorporating the fastest components available. We design, manufacture, test, and burn-in our subsystems before they go out the door for guaranteed reliability—all you have to do is plug them in! And we can get your application up and running in record time.

You Can Count On Us

Call our Marketing Hotline at **(408) 492-8303, Dept. TS90** today for technical information. Or call (408) 492-8225 for a copy of our Subsystems Short-Form Catalog, Custom Modules Information Packet, and 1989 Data Book Supplement with details about our RISC modules and subsystems.

IDT, Corporate Marketing,
2975 Stender Way, Santa Clara, CA
95052-8015, FAX 408-492-8674.

When cost-effective performance counts

Integrated
Device Technology

RISC SubSystem is a trademark of Integrated Device Technology, Inc.

CIRCLE NO. 43

printers. But this listing of capabilities is merely the beginning.

One way to categorize the programs is to divide them into numeric solvers and symbolic solvers. Think of the numeric solvers as sophisticated versions of a hand-held calculator. Like most calculators, they don't provide answers until you plug in numeric values for your variables. (For information on a calculator that handles symbolic math, see pg 121.) On the other hand, the symbolic solvers, which include Derive, Maple, Mathematica, and PC Macsyma, manipulate and simplify formulas. This ability to handle problems at the symbolic level and to simplify equations reveals much about your problem before you start assigning numerical values to variables.

If the list of capabilities suggests to you that these programs can be

Math software helps consultant get answers fast

***Jerry Tapper** uses general-purpose math software to derive and document answers to problems posed by his consulting clients. (Photo by Gary Legg)*

Jerry Tapper operates Electromechanical Solution Consultants from the Boston suburb of Swampscott, MA. He also teaches a 3-course evening sequence in electronics at his alma mater, Northeastern University in Boston. Although Tapper's approach to problem solving depends heavily on theory, he isn't a typical academician. He started consulting after 20 years of nuts-and-bolts electronic engineering. He designed automatic assembly and test systems for custom switch assemblies used in automobiles and appliances.

Tapper's business depends on getting answers fast—and he has to be able to back up those answers. A job he performed recently for a hybrid-assembly house shows how math software helps him to understand a problem and support his understanding with the kind of thoroughly documented analysis that puts clients at ease.

The hybrid house had agreed to assemble a circuit for a government contractor. At the company that let the contract, nobody was left who had been involved in the design of the circuit. When the hybrid house built hundreds of circuits according to the documentation provided them by the government contractor, very few of the circuits worked. The result was an acrimonious dispute between the contractor and the hybrid house, each of which blamed the other for the pitiful yield. The hybrid house called Tapper to settle the argument.

The circuit included signal conditioning, filtering, and an analog comparator. Tapper uses analog simulation programs in his work and teaching, but for this job, he chose a general-purpose math package, Universal Technical Systems' TK Solver Plus. He chose TK because it let him control every parameter involved in the circuit's operation. With simulators, he says, you are at the mercy of the device models in the simulator's library—unless you want to take the time to develop your own models.

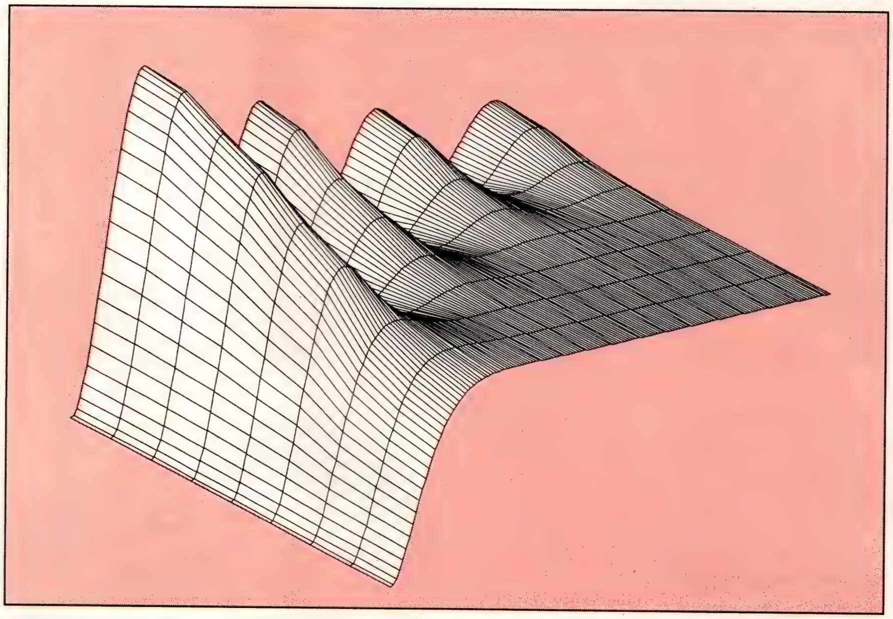
The heart of the circuit was the comparator. From the hybrid assembly's input specs, Tapper determined that he could use a triangular wave to conservatively approximate the exponentially rising and falling waveshape produced by the signal conditioner driving the filter that preceded the comparator. The comparator was guaranteed to respond in 500 nsec, and TK showed that if conditions were perfect, the comparator's input would exceed the threshold for tens of microseconds. But in the ideal case, the peak voltage driving the comparator never reached a value over 100 mV above the threshold. Moreover, in series with the comparator input, there was a diode whose uncompensated forward voltage reduced the signal level further as temperature increased. Thus, using TK, Tapper demonstrated and documented that a combination of a small temperature rise and a buildup of component-value tolerances could cause the circuit to fail.

complex, you're right. But, as with so many other characteristics, the complexity level varies greatly among the products, and many vendors strenuously object to the "complex" label. Nevertheless, if you want to use a high percentage of a mathematical package's capabilities, plan on spending more time learning to use the software than you would learning to use most word processors or spreadsheets.

Pioneers faced problems

Despite the effort you'll have to expend learning how to use the software, your task will be simple compared to that of the engineers who used computers for technical problem solving in computing's early days. Solving engineering and scientific problems was one of the earliest applications for large-scale computers. Although many of those early machines had no more power than today's desktop PCs, they occupied entire rooms—and sometimes, entire buildings. The engineers who first used computers for such tasks had to write their own software. At first, they used machine language and later on assembly language. Eventually, Fortran was developed to simplify solving technical problems. The language has served the engineering and scientific communities well for more than three decades.

Despite the advent of many more modern languages, such as, C, many scientists and engineers still use Fortran for technical computations. But Fortran predates interactive computing of the type possible on personal computers. Also, Fortran and C are languages. If you want to apply them to solving problems, you must write programs.



A surface plot provides *an unusual way of looking at a system's transient response. Here, Matlab shows you how the response varies as a function of time and also what happens as you vary system parameters.*

The packages reviewed for this article attempt to go beyond Fortran and C by making the computer's calculating ability more accessible and more interactive. None requires you to write programs, though several—including PC Macsyma, Maple, Mathematica, Matlab, and TK Solver Plus—provide their own languages that you can use if you are so inclined. Furthermore, most of the packages take advantage of modern computers' ability to produce graphical outputs. The 2- and 3-dimensional plots these programs produce can be invaluable aids in visualizing a problem's solution.

Long before the advent of microcomputers and even longer before the widespread use of computer graphics, work began on software whose problem-solving abilities would go considerably beyond those of Fortran. The first symbolic solver originated at MIT's famed Artificial Intelligence Laboratory in the late 1960s as part of Project MAC. (The acronym has nothing to do with the Macintosh, which didn't appear until 1984. MAC stands for multiple-access computing.) A program that ran on a Digital Equipment PDP-10 was a direct antecedent of today's PC Macsyma. The "Mac" in Macsyma relates to the program's Project MAC heritage.

PC Macsyma is just one of the versions of the program now marketed by Symbolics Inc. The other versions run on workstations and minicomputers. Symbolics has given the PC version a Macintosh-like interface with pull-down menus. But PC Macsyma's origins are evident in the hardware it requires. It needs an 80386-based PC with a minimum of 4M bytes of RAM and at least 17M bytes of free space on a hard disk. If your computer has 10M bytes or more of RAM or a numeric processor, operation speeds up noticeably.

For $1995, the single-copy price without educational discounts, PC Macsyma gives you a lot. The algorithms it uses, including artificial-intelligence techniques for parsing equations, have been honed and refined for 20 years. Though the PC version is new, Macsyma is a robust, proven product with great capabilities and extensive on-line help. But Symbolics admits that there are less expensive programs,

IBM PC Image Processing Highlights. **No. 3 in a series.**

MODEL	DESCRIPTION	RESOLUTION Spatial	Gray Levels	Number
DT2862-60Hz⁶ **DT2862-50Hz⁶**	Arithmetic Frame Grabber	512 x 512	256	8¹
DT2862-60Hz⁶ w/ DT2858⁶	Frame Grabber & Frame Processor	512 x 512	256	8¹
DT2862-50Hz⁶ w/ DT2858⁶	Frame Grabber & Frame Processor	512 x 512	256	8¹
DT2861-60Hz⁶ **DT2861-50Hz⁶**	Arithmetic Frame Grabber	512x512	256	8
DT2861-60Hz⁶ w/ DT2858⁶	Frame Grabber & Frame Processor	512z512	256	8
DT2861-50Hz⁶ w/ DT2858⁶	Frame Grabber & Frame Processor	512x512	256	
DT2851-60Hz⁶ **DT2851-50Hz⁶**	High Resolution Frame Grabber	512 x 512	256	

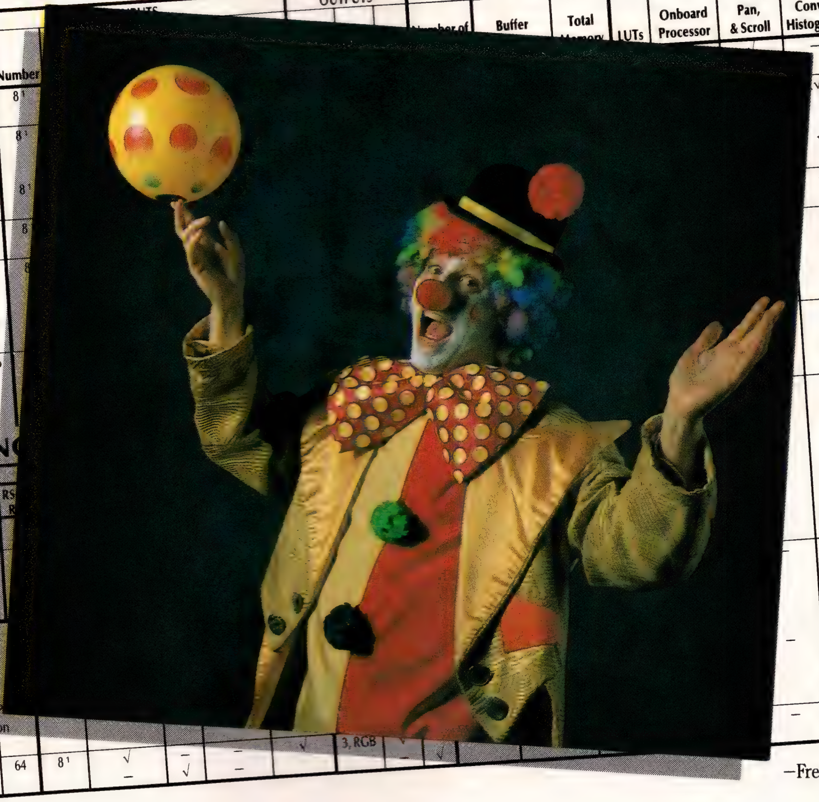
COLOR IMAGE PROCESSIN

MODEL	DESCRIPTION	RESOLUTION Spatial	Number of Colors
DT2871-60Hz **DT2871-50Hz**	(HSI)*Color*™ Frame Grabber	512 x 512	16.8 million
DT2871-60Hz w/ DT2858	Color Frame Grabber and Frame Processor	512 x 512	16.8 million
DT2871-50Hz w/ DT2858	Color Frame Grabber and Frame Processor	512 x 512	16.8 million

DT2853-SQ-60Hz⁶ **DT2853-SQ-50Hz⁶**	Low Cost, Square Pixel Frame Grabber	512 x 512 Square P Option					
DT2803-60Hz **DT2803-50Hz**	Low Cost Frame Grabber	256 x 256	64	8¹	√ —	— √	—

OUTPUTS	MEMORY	MEMORY Buffer	Total	LUTs	Onboard Processor

PROCESSING Zoom, Pan, & Scroll	NxM Conv., Histogram	Real-Time Frame Aver. Math & Logic	Hardw Windo
	—	8-bit	√
	√	8-bit or 16-bit²	√
	√	8-bit or 16-bit²	√
	—	8-bit	
	√	8-bit or 16-bit²	
	√	8-bit or 16-bit²	
	—	4-bit	
	√	4-bit or 16-bit²	
	√	4-bit or 16-bit²	
	—	4-bit	
—	—	4-bit	
—	—	—	



—Fred Molinari, President

Why clown around in black and white when you can do it in color...just as easily.

The DT2871 Frame Grabber.
The next logical step.

Now, moving from monochrome to color image processing is as easy as plugging our DT2871 (HSI) *Color*™ Frame Grabber into your IBM® PC AT®-compatible computer.

The DT2871 features real-time 24-bit color capture and display. It also performs real-time RGB/HSI and HSI/RGB color-space conversion for processing captured images in either the red-green-blue or hue-saturation intensity domain . . . intensity being the link to monochrome processing which performs gray scale operations.

The DT2871 connects directly to DT-*Connect*™ processor boards for faster compute-intensive color processing. And, is supported by our Aurora™ software for accelerated application development.

Now, color image processing can be much less complicated and quicker to execute.

So, add a little color to *your* act.

Call (508) 481-3700
In Canada, call (800) 268-0427

FREE 1990 Image Processing Handbook.

DATA TRANSLATION®

World Headquarters: Data Translation, Inc., 100 Locke Drive, Marlboro, MA 01752-1192 USA, (508) 481-3700 Tlx 951646
United Kingdom Headquarters: Data Translation Ltd., The Mulberry Business Park, Wokingham, Berkshire RG11 2QJ U.K. (0734) 793838 Tlx 94011914
West Germany Headquarters: Data Translation GmbH, Stuttgarter Strasse 66, 7120 Bietigheim-Bissingen, West Germany 07142-54025
International Sales Offices: Australia (2) 662-4255; Belgium (2) 466-8199; Canada (416) 625-1907; China (1) 868-721 x4017; Denmark (42) 274511; Finland (0) 372144; France (1) 69077802; Greece (1) 361-4300; Hong Kong (5) 448963; India (22) 23-1040; Israel (52) 545685; Italy (2) 82470.1; Japan (3) 502-5550, (3) 348-8301, (3) 555-1111; Korea (2) 756-9954; Netherlands (70) 99-6360; New Zealand (64) 9-545313; Norway (2) 53 12 50; Portugal (1) 545313; Singapore (65) 7797621; South Africa (12) 8037680/93; Spain (1) 455-8112; Sweden (8) 761-7820; Switzerland (1) 723-1410; Taiwan (2) 702-0405.

DT-Connect, (HSI) Color and Aurora are trademarks, and Data Translation is a registered trademark of Data Translation, Inc. All other trademarks and registered trademarks are the property of their respective holders.

CIRCLE NO. 44

designed from the outset to run on personal computers, that solve some problems faster and provide more attractive graphic outputs.

Math software's Waterloo

Another symbolic solver, Maple, can also trace its origins to an educational institution. Work on Maple began at the University of Waterloo, Ontario. Waterloo Maple Software distributes versions of Maple for 80386-based IBM PC- and PS/2-compatible computers, workstations, and mainframes. In North America, Brooks-Cole Publishing distributes a Macintosh-based version. Actually, there are two Macintosh versions, one for 68000-based machines with at least 1M byte of RAM and another for Macs with a 68030 µP. Brooks-Cole ships both versions in one box, however.

The symbolic solver most closely associated with microcomputers in the minds of some personal-computer users, especially Macintosh users, is Wolfram Research's Mathematica. As did the developers of Macsyma and Maple, many of Mathematica's developers met at a university—the University of Illinois. There are two versions of Mathematica for the Macintosh and three for IBM PC-compatible machines. (All IBM PC-compatible machines must have an 80386 CPU.) There are also versions for workstations, including the Next computer.

Another symbolic solver, Soft Warehouse Inc's Derive, takes a different approach than Macsyma,

Table 1—Representative mathematical software packages

Vendor	Package	Base US list price	Computer	Minimum CPU[1]	Numeric processor required?	Minimum memory (Bytes)	Hard disk[2]	Comments
AISN Software	Table Curve	$159	IBM PC		Suggested	640k	Suggested	Uses statistical methods to fit curves—defined by 211 equations—to date. Plots. Reads WKS files.
Asyst	Asystant	$245	IBM PC		No	512k	Suggested	Matrix operations, differential equations, statistics, curve fitting, plotting.
Borland	Eureka	$167	IBM PC		Supported	384k		Solves linear and nonlinear equations and systems of equations including ones involving complex numbers. Evaluates derivatives and definite integrals. Plots. Performs trigonometric and statistical calculations.
		$195	Macintosh		Supported	512k		
Brooks-Cole	Maple	$395	Macintosh		See story	1M	Required	Symbolic solver with its own programming language. Also operates in immediate mode. Library of 1500 routines includes source code. Maple is a full-featured and comprehensive mathematical problem-solving tool.
Waterloo Maple		$1100	IBM PC	80386		NS[3]	NS	
BV Engineering	PC Hyper-calculator	$49.95	IBM PC			128k	No	Emulates Hewlett-Packard 11c scientific and 12c financial calculators.
	Matrix Magic	$95	IBM PC			NS	NS	Interactive, menu-driven matrix-manipulation and test program. Handles matrices to 20 rows by 20 columns.
DSP Development	DaDisp	$895	IBM PC			640k	No	Spreadsheet for waveforms. Performs math operations including FFTs on waveforms and displays results in on-screen windows.
		$1695		80386	No	2.64M		
Mace[4]	Cornucopia	$29.95	IBM PC		NS	NS	NS	A disk of shareware. One of the programs is an antecedent of Matlab that performs some of the functions of the genuine article.
Mathsoft	MathCad	$495	IBM PC		No	512k	Suggested	Performs trigonometric, hyperbolic, complex, Bessel, matrix, statistical, cubic-spline, and Fourier-transform calculations as well as 2- and 3D plotting. Additional IBM PC statistics-function packs available.
		$495	Macintosh		No	1M		
The Math Works	PC-Matlab	$795	IBM PC		Yes	512k	Required	Interactive integrated analysis program specializing in matrix operations. Includes its own language that some users liken to APL without the special symbols. Math functions include Bessel functions. Handles complex numbers. Computes direct and inverse FFTs. Plots in two and three dimensions. A series of "toolbox" add-ons handles such areas as DSP, digital-filter design, filter response simulation and control-system design.
	AT-Matlab	$795	IBM PC/AT	80286	Yes	1.64M	Required	
	386-Matlab	$1495	IBM PC	80386	Note 5	Note 6	Required	
	Edu-Matlab	$895	Macintosh		Yes	1M	Required	
	Mac II-Matlab	$895	Macintosh	68030 68000	No Yes	1M	Required	

Notes:
1. Unless otherwise noted, packages listed for IBM PCs run on machines equipped with an 8088 CPU and a graphics display adapter and those listed for the Macintosh require only a 68000 CPU. Unless noted, packages support a numeric coprocessor but do not require one.
2. If this entry is blank, the program can use a hard disk but the vendor considers operation from floppy disks to be completely satisfactory.
3. Not specified. Vendor did not supply the data.
4. This company is not related to a company with a similar name that publishes utility software.
5. 386/Weitek-Matlab, a special version of 386-Matlab, supports the Weitek 1167 and 3167 math coprocessors. Price: $1995.
6. Vendor recommends at least 2M bytes of extended RAM.
7. $5 shipping and handling if ordered from UDH.

Maple, and Mathematica. Derive was designed from the outset to operate on computers with very modest hardware. It lacks a programming language of its own, but its menu-driven user interface makes getting started with the program and using its graphics capabilities easy. Derive, the successor to an earlier PC-based symbolic solver called Mumath, is an example of programs whose authors started out to create tools for use on personal computers.

Nearly two decades ago, while some programmers and mathematicians were working on math software to run on minicomputers, a few visionaries realized that personal computers could bring the computer-aided solution of mathematical problems to a very large audience. One of them was Dr Milos Konopasek, now vice president of Universal Technical Systems Inc (UTS). After developing a mathematical problem-solving program called QAS (question-answering system) that ran in a time-sharing mode on a PDP-10 computer at the University of Manchester, England, in the early 1970s, he emigrated to the US.

Konopasek was teaching at Georgia Tech in the mid '70s when he first encountered a personal computer. It came from the now-defunct Intelligent Systems. He rewrote QAS to run on the machine. Basic was the native language of those early PCs, and Konopasek wrote the first microcomputer ver-

Vendor	Package	Base US list price	Computer	Minimum CPU[1]	Numeric processor required?	Minimum memory (Bytes)	Hard disk[2]	Comments
MCAE	Cedar	$895	IBM PC	80286		640k	Required	Equation solver, advanced scientific calculator, and intelligent drawing system combined under MS windows.
MicroMath	LaPlace	$249	IBM PC		No	640k	Suggested	Simulates physical systems by numerically inverting LaPlace transforms. Plots 2D graphs.
	Minsq	$179	IBM PC		No	640k	Suggested	Performs least-squares parameter estimation. Plots 2D graphs. Module that works with models expressed as LaPlace transforms planned. Basic-like model-entry language.
	Graph	$79	IBM PC		No	640k	Suggested	X-Y plotting where Minsq isn't needed.
Prescience	Theorist	$379.95	Macintosh			1M	Suggested	Symbolic solver. What-you-see-is-what-you-get entry of equations. Symbolic and matrix algebra. Taylor-series expansion. Bessel, gamma, and error functions.
Soft Warehouse	Derive	$200	IBM PC		No	512k	No	Symbolic solver with menu-driven interface. Handles arithmetic, algebra, calculus, 2- and 3-D plots, exponential, log, trig, and hyperbolic functions.
Symbolics	PC Macsyma	$1995	IBM PC	80386		4M	Uses 17M bytes	See article text. Full-featured symbolic solver. Has pull-down menus as well as command-driven operation. Has own language. Interfaces with Fortran, C, and Tex.
TriMetrix	Axum	$495	IBM PC			640k	Required	2- and 3-D graphing, contour plots, Smith charts, statistics, curve fitting, smoothing, and data editing. Imports 1-2-3 and dBase files.
UDH Enterprises	Cmpcalc3	Free[7]	IBM PC		No	NS	No	Turns computer into a programmable scientific calculator for complex numbers. Text display only. Cmpcalc4 handles multiple and re-entrant programs to 500 steps.
	Cmpcalc4	$39.95	IBM PC		Supported	NS	No	
Universal Technical Systems	TK Solver Plus	$395[8]	IBM PC			512k[9]		See article text. Numeric solver with its own programming language. Add-on modules tailor TK to specific application areas. "Backsolving" allows you to add constraints after initial solution. Produces 2- and 3-D graphs.
	TK Solver Plus	$395	Macintosh			512k[9]		
Wolfram Research	Mathematicia	$495	Macintosh		No	1M	Suggested	Symbolic solver with its own programming language and extensive 2- and 3-D graphics capabilities. Integer and mathematical functions, numerical matrix operations, Fourier transforms, generalized least-squares fit, polynomial and rational-function operations, calculus, equation solving, and symbolic matrix and tensor operations.
		$795		68030	Yes	2M[10]	Required	
		$695	IBM PC	80386	No	1.64M	Required	
		$995			80287/387			
		$1295			Weitek			

8. Version that supports expanded memory, $495. MiniTK, a working subset of TK Solver Plus, $20. MiniTK buyers can deduct $20 from price of TK Solver Plus.
9. Some add-on modules for IBM PCs require 640k bytes of RAM. Some Macintosh add-on modules require 1M byte of RAM. Some add-ons also require a hard disk.
10. 4M bytes recommended.

sion of QAS in Basic. The program's essential "backsolving" capability—its ability to accept constraints on previously unconstrained variables and thus produce new and possibly more practical solutions—took fewer than 120 lines of code.

Shortly after he wrote the microcomputer version of QAS, Konopasek became aware of Visicalc, the first commercial spreadsheet program. At first, Visicalc ran only on the Apple II, and was a product of a Massachusetts company, Software Arts. Konopasek proposed a numerical solver for scientific and technical problems as an add-on to Visicalc.

Software Arts wasn't interested in marketing a special version of Visicalc, though. So a separate product, TK!Solver, the first microcomputer-based numeric solver with backsolving capability, was born. (The "TK" in the name stands for tool kit.) Eventually, Lotus Development (Cambridge, MA) acquired Software Arts and TK, but didn't want to market software for technical applications. Lotus sold TK to UTS, which has enhanced the product and now sells it as TK Solver Plus for both the IBM PC family and the Macintosh.

Unlike programs that began as workstation and minicomputer software and migrated downward to microcomputers, TK has migrated upward to such machines as DEC VAXes and Sun and Apollo workstations.

TK uses constructs called

For more information . . .

For more information on the math software discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

AISN Software
Box 32277
Phoenix, AZ 85064
(602) 266-1925
Circle No. 700

Asyst Software Technologies
100 Corporate Woods
Rochester, NY 14623
(800) 348-0033; in NY,
(716) 272-0070
FAX 716-272-0073
Circle No. 701

Borland International
4585 Scotts Valley Rd
Scotts Valley, CA 95066
(408) 438-8400
FAX 408-439-9273
Circle No. 702

Brooks-Cole Publishing Co
511 Forest Lodge Rd
Pacific Grove, CA 93950
(408) 373-0728
FAX 408-375-6414
Circle No. 703

BV Engineering
2023 Chicago Ave, Suite B13
Riverside, CA 92507
(714) 781-0252
TWX 650-308-9864
Circle No. 704

DSP Development Corp
1 Kendall Square
Cambridge, MA 02139
(617) 577-1133
FAX 617-577-8211
Circle No. 705

MACE Inc
2313 Center Ave
Madison, WI 53704
(608) 244-3331
Circle No. 706

Mathsoft Inc
1 Kendall Square
Cambridge, MA 02139
(800) 628-4223; in MA,
(617) 577-1017
FAX 617-577-8829
Circle No. 707

The Math Works Inc
21 Eliot St
S Natick, MA 01760
(508) 653-1415
FAX 508-653-2997
Circle No. 708

MCAE Technologies Inc
3160 De La Cruz Blvd, Suite 201
Santa Clara, CA 95054
(408) 748-0334
FAX 408-748-1915
Circle No. 709

MicroMath Scientific Software
2034 E Fort Union Blvd
Salt Lake City, UT 84121
(801) 943-0290
FAX 801-943-0299
Circle No. 710

Prescience Corp
814 Castro St, Suite 103
San Francisco, CA 94114
(415) 282-5864
Circle No. 711

Soft Warehouse Inc
3615 Harding Ave, Suite 505
Honolulu, HI 96816
(808) 734-5801
FAX 808-735-1105
Circle No. 712

Symbolics Inc
New England Executive Park East
Burlington, MA 01803
(617) 221-1250
FAX 617-221-1099
Circle No. 713

TriMetrix Inc
444 NE Ravenna Blvd, Suite 210
Seattle, WA 98115
(206) 527-1801
FAX 206-547-0328
Circle No. 714

UDH Enterprises Inc
1000 E William St, Suite 100
Carson City, NV 89701
(800) 888-7070, ext 103;
in NV, (702) 885-9918
Circle No. 715

Universal Technical Systems
1220 Rock St
Rockford, IL 61101
(815) 963-2220
FAX 815-963-8884
Circle No. 716

Waterloo Maple Software
160 Columbia St W
Waterloo, Ont, Canada N2L 3L3
(519) 747-2373
FAX 519-747-5284
Circle No. 717

Wolfram Research
Box 6059
Champaign IL 61826
(800) 441-6284; in IL,
(217) 398-0700
FAX 217-398-0747
Circle No. 718

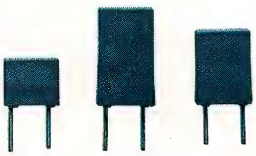
VOTE . . .

Please also use the Information Retrieval Service card to rate this article (circle one):

High Interest 515 **Medium Interest 516** **Low Interest 517**

SIEMENS

All good things come in threes



CIRCLE NO. 48

PICO
DC-DC CONVERTERS
Wide Input Range 5 to 72V DC

Regulated 5 Watt to 30 Watt

- 386 Standard Models
- Single, Dual and Triple Output
- Output Voltages of 5, 9, 12, 15, 24, 28 and 48 Volts DC Standard
- Ambient Temperature Range −25°C to +70°C with No Heat Sink or Electrical Derating
- All Units Shielded
- 500V DC Isolation Input to Output
- New PLR Series Features .300″ ht.
- New NR Series, up to 30 Watts-50 Models-30 Triple Outputs

OPTIONS AVAILABLE
- *Expanded operating temp (−55°C to +85°C)*
- *Stabilization Bake (125°C ambient)*
- *Temperature Cycle (−55°C to +125°C)*
- *Hi Temp, full power burn in (100% power, 125°C case temp)*

Delivery—stock to one week

SEE EEM, THOMAS REGISTER OR SEND DIRECT FOR FREE PICO CATALOG

PICO Electronics, Inc.
453 N. MacQuesten Pkwy. Mt. Vernon, N.Y. 10552

Call Toll Free **800-431-1064**
IN NEW YORK CALL **914-699-5514**

PICO also manufactures over 700 standard DC-DC Converters, AC-DC Power Supplies and over 2500 Miniature Transformers and Inductors

CIRCLE NO. 22

"sheets." For example, there are rule and variable sheets. In today's software lexicon, TK's sheets hold different classes of objects. This object-oriented structure is well suited to the creation of sets of models that solve classes of problems. UTS sells these model sets as add-ons to TK and calls them TK Solver Packs. One Pack is for electrical engineering. In a recent effort aimed at structural engineers, UTS created a Pack of 800 models that solve the equations in Roark and Young's *Formulas for Stress and Strain.* TK's backsolving ability, a hallmark of the program from the beginning, is especially useful with structural problems.

A program that shares TK's concept of add-on modules for specific application areas is Matlab from The Math Works. Two of Matlab's many add-ons are the Control-System Toolbox and the Signal-Processing Toolbox.

The IBM PC- and Macintosh-based versions of Matlab suit specific hardware configurations. For example, there are two separate versions of Matlab for the Macintosh—one for 68000-based machines and the other for 68030-based Macs and 68000-based Macs with a 68881 coprocessor. In the IBM PC world, there are versions for 8086/8088-based machines with a coprocessor, 80286-based machines with a coprocessor, 80386-based machines without a coprocessor, and 80386-based machines with a Weitek coprocessor. Other versions run on VAXes and several workstations.

As with many math programs available for a variety of machines, Matlab allows you to easily interchange data among computers. It also allows for easy interchange of data with other programs.

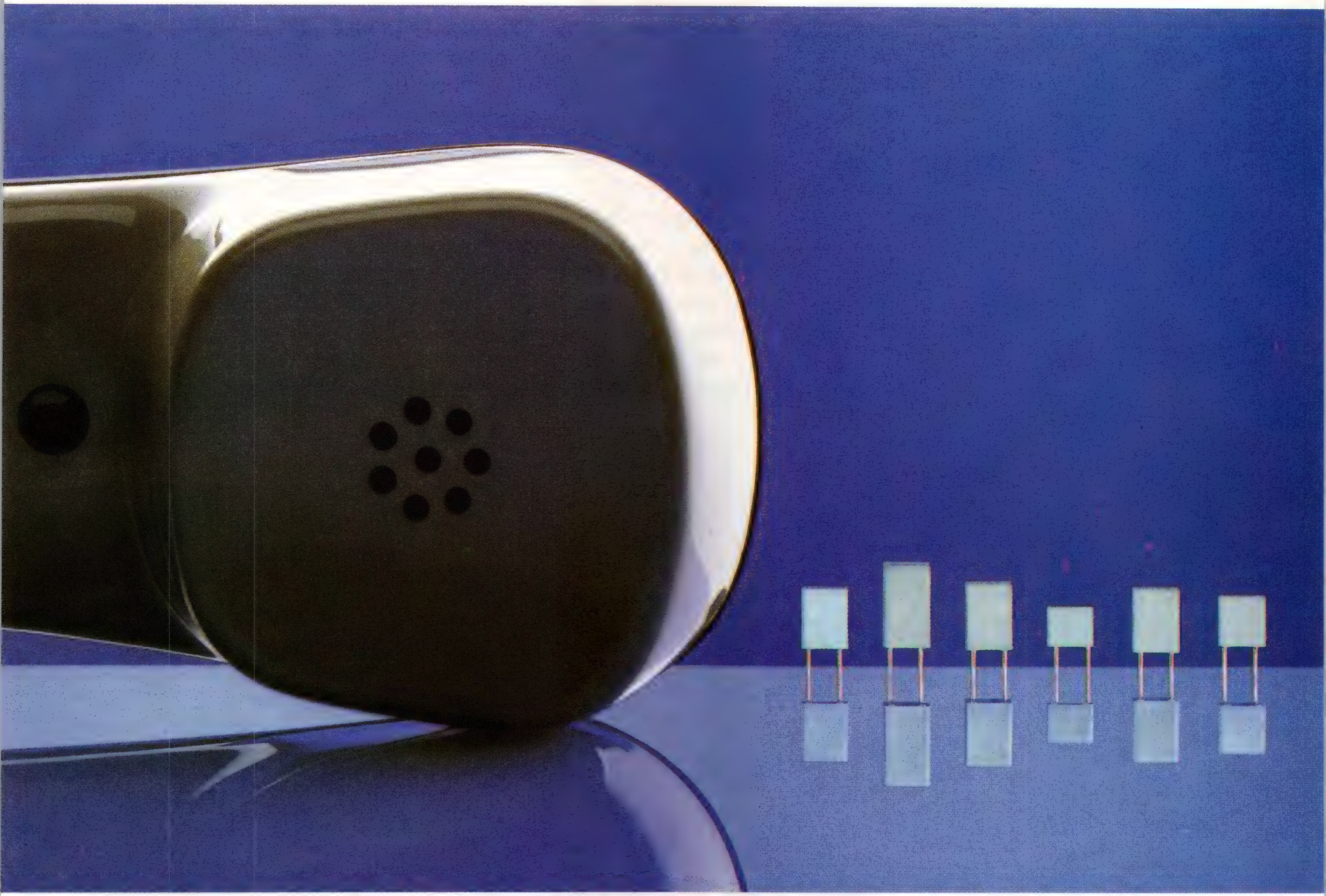
A capable numeric solver with extensive graphic abilities, modest hardware requirements, and an intuitive menu-driven interface is Mathsoft's MathCad. The latest versions (V2.5 for the IBM PC family; V2.0 for the Macintosh) have received raves from reviewers.

MathCad lets you create documents similar to those you'd produce with a word processor. Just as with a word processor, you can enter free-form text. But unlike a word processor, MathCad lets you enter equations and, through clever use of graphics, displays them on the screen with all of their specialized symbols. Somewhat unexpectedly, the use of graphics to display symbols is a feature of the IBM PC version of MathCad as well as of the Macintosh version. If your company uses both PCs and Macintoshes, you can move MathCad documents between the computers with relative ease.

If you often work with equations and numbers, chances are that you find grinding out answers, even with the aid of a calculator, a tiresome, error-prone process. Worse yet, you can become so focused on getting answers that you lose sight of the original problem. When you face such a situation, let your personal computer come to your rescue. With mathematical software like that discussed here, your computer will take on the tedious parts of the job and let you be analytical and creative. **EDN**

Article Interest Quotient
(Circle One)
High 515 Medium 516 Low 517

SIEMENS



First – MKT capacitors

Metallized polyester film capacitors with 5-mm lead spacing from Siemens

Our selection of MKT capacitors with 5-mm lead spacings is now fully rounded off: rated voltages start at 50V and go right through to 400V. And capacitances cover almost four decimal levels from 1000 pF to 3.3 μF. Just try to find a bigger range, not to mention a better one.

Our small MKT capacitors are noted for their supreme quality. This is the benefit of their stacked-film technology: regeneration is very good – pulse handling is more than high (CECC). And with their cases these capacitors are excellent for automatic insertion.

MKT capacitors from Siemens can be used virtually anywhere. After all, we designed them for wide-ranging applications: small, practical and right in price. For a rundown on the entire line-up just write

Siemens AG
Group Passive Components
and Electron Tubes, PR VF
Balanstraße 73
D-8000 München 80
West Germany
quoting "MK capacitors".

The components make it – Siemens

A19100-PR102A-X-7600 MC&D

CIRCLE NO. 49

"WE DEPEND ON **EDN'S MAGAZINE** AND **NEWS EDITIONS** TO DELIVER THE SPECIFICS ON MAXIM PRODUCTS TO POTENTIAL CUSTOMERS."

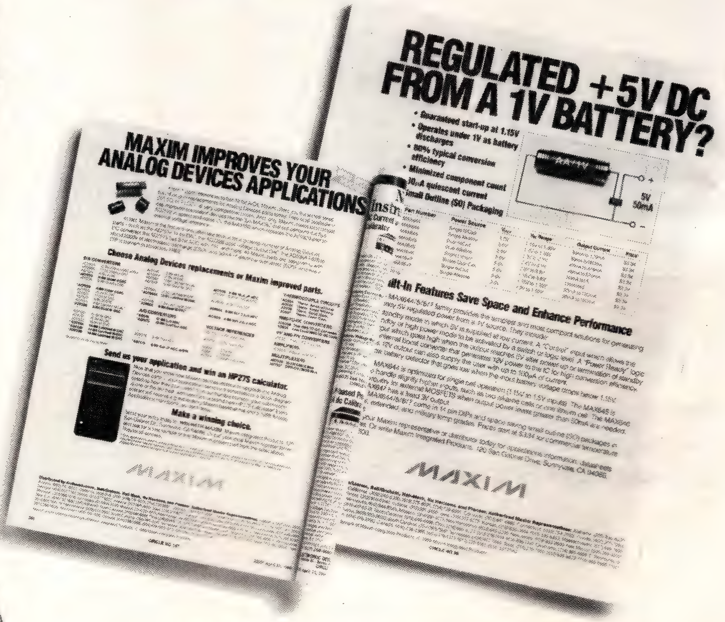
Mike Dikas
Director of Communications
Maxim Integrated Products

Maxim Integrated Products is one of today's fastest growing international suppliers of quality analog ICs. In the past five years they have introduced more than two hundred proprietary and improved second source devices.

Director of Communications, Mike Dikas has piloted Maxim's advertising program since its inception. "EDN's magazine and news editions have played a significant role in introducing many of our new products. In the past two years, over 25,000 EDN Magazine and News Edition readers have responded to Maxim ads, product releases and articles," says Mike. "Our ads consistently fall in the top 10% in reader response in both editions of EDN. What's even more amazing is that we typically get less than 5% duplication of responses to the same ad in both the Magazine and News Editions."

What's that mean for Maxim? "Since both editions deliver the same circulation, it's apparent to us that the same engineers read both the Magazine and News Editions for different reasons. Given Maxim's charter of product proliferation, EDN's in-depth coverage of technical issues and timely coverage of new products are both of the utmost importance to Maxim."

Mike Dikas believes in the complementary roles of EDN Magazine and EDN News Editions.



MAXIM IMPROVES YOUR ANALOG DEVICES APPLICATIONS

Choose Analog Devices replacements or Maxim improved parts.

Send us your application and win an HP27S calculator.

Make a winning choice.

MAXIM

REGULATED +5V DC FROM A 1V BATTERY?

- Guaranteed start-up at 1.15V
- Operates under 1V as battery discharges
- 80% typical conversion efficiency
- Minimized component count
- Small Outline (SO) Packaging

Built-In Features Save Space and Enhance Performance

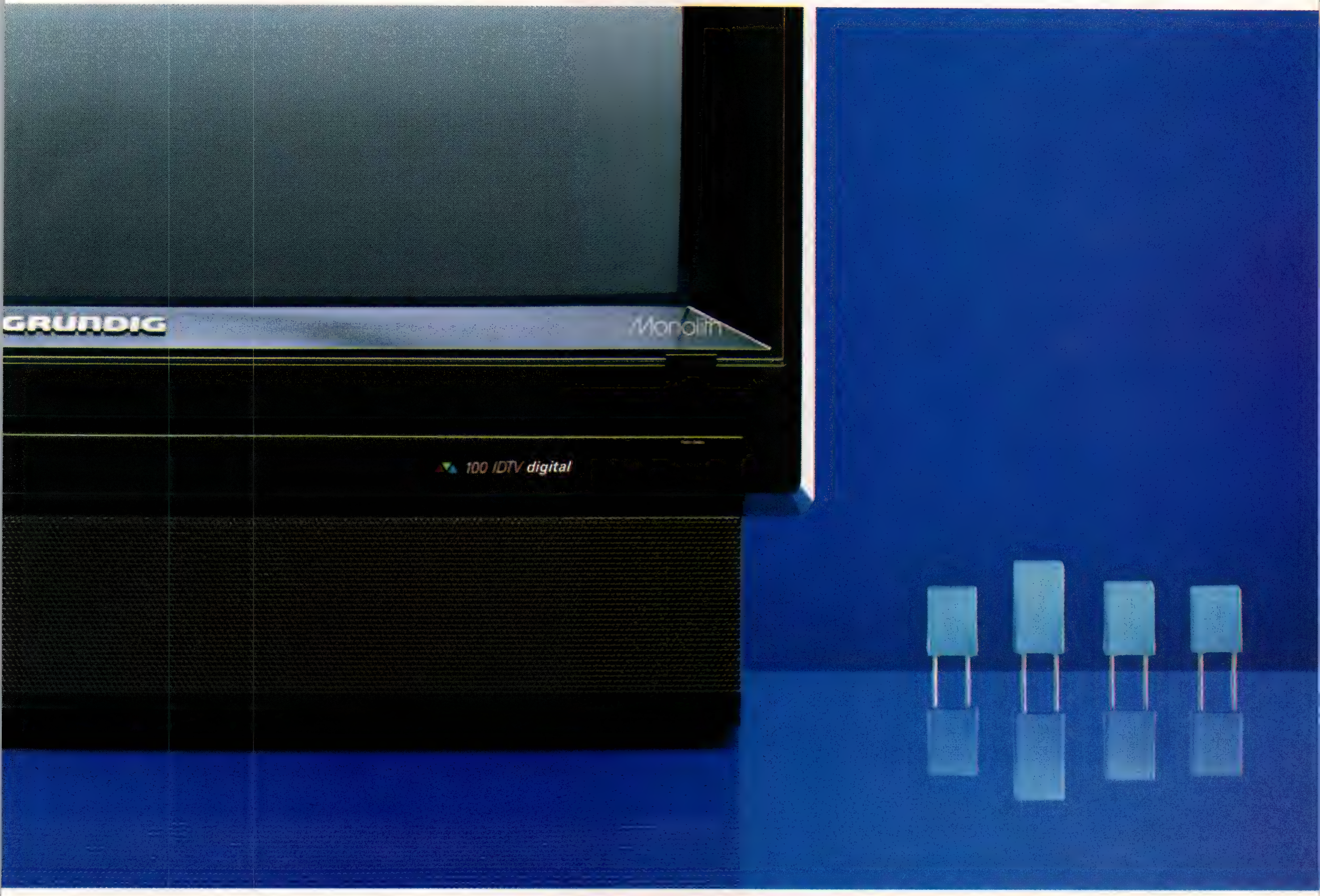
MAXIM

EDN Magazine and News Editions work for
Maxim Integrated Products.
They can work for you.

EDN

A Partnership in Power and Prestige Worldwide.

SIEMENS



Second –
MKP capacitors

New: metallized polypropylene film capacitors with 5-mm lead spacing from Siemens

Our MKP capacitors are designed for extra demands. Whether in the radiofrequency range, in video electronics, for switch-mode power supplies or in pulse circuits, these new miniature capacitors show themselves from their best side: very high pulse handling with minimal dissipation factor (low self-heating).

Siemens MKP capacitors are already on hand for 47 through 150 nF at 100V and for 10 through 100 nF at 250V rated voltage. Other models are on the way. Stacked-film technology still has a lot to show.

MKP capacitors are self-healing and can be inserted automatically in their flame-retardant plastic cases. For full details just write

Siemens AG
Group Passive Components
and Electron Tubes, PR VF
Balanstrasse 73
D-8000 Munich 80
West Germany
quoting "MK capacitors".

The components make it – Siemens

A19100-PR102B-X-7600 MC&D

CIRCLE NO. 50

Finding The Right Embedded Graphics Processor Can Be Harder Than You Think.

Embedded graphics applications can range from PC displays to entertainment systems. So you need a fast graphics system processor that's fully programmable for every high-resolution application.

And you don't need to waste a lot of time trying to find one.

That's why Marshall Industries carries the latest graphics system processor from Texas Instruments. Ready to ship in production quantities.

With a 60 million bit-per-second draw rate, seven and one half million instruction-per-second capacity and the ability to draw open and filled geometric shapes, the TMS34010 is available in 40, 50 and 60 MHz speeds. All these features on a single chip make this the most cost-effective graphics processor on the market.

Even better, thanks to Marshall's leadership, you get the full support of a national distributor. Support which includes developer's kits for 34010-based PC systems, software assemblers, hardware emulators, evaluation boards, and extensive documentation. Not to mention the security that comes from dealing with one of TI's largest distributors.

So if finding a reliable source for your embedded graphics solutions has you on pins and needles, call Marshall today.

We won't stick you with anything but a great graphics processor.

Marshall

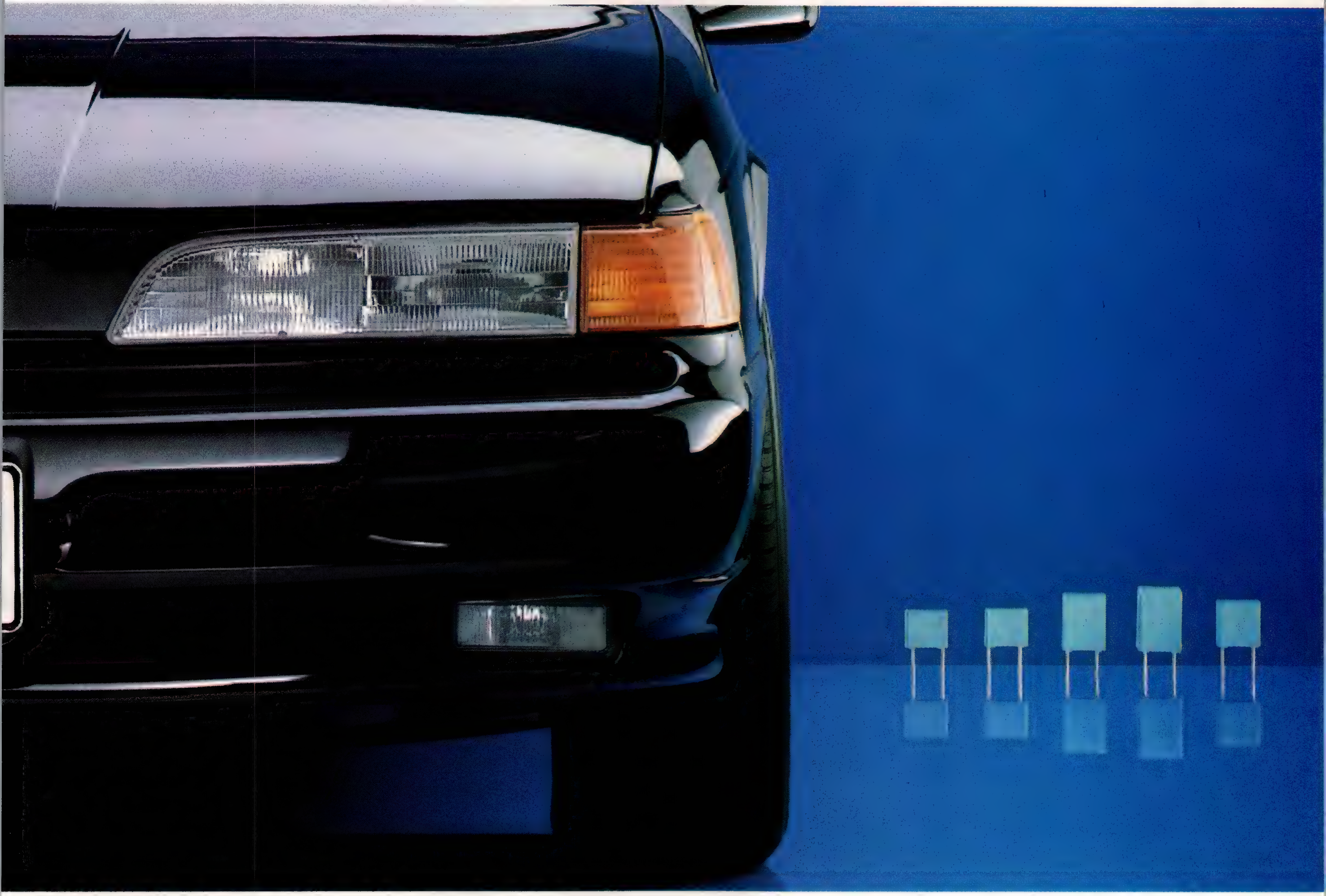
(*Authorized Locations)
AL Huntsville (205) 881-9235*
AZ Phoenix (602) 496-0290*
Tucson (602) 790-5687*
CA Irvine (714) 458-5301*
Los Angeles (818) 407-4100*
Sacramento (916) 635-9700*
San Diego (619) 578-9600*
San Francisco (408) 942-4600*
CO Denver (303) 451-8383*
CT Connecticut (203) 265-3822*
FL Ft. Lauderdale (305) 977-4880*
Orlando (407) 767-8585*
Tampa (813) 573-1399*
GA Atlanta (404) 923-5750*
IL Chicago (312) 490-0155*
IN Indianapolis (317) 297-0483*
KS Kansas City (913) 492-3121*
MA Boston (508) 658-0810*
MD Maryland (301) 622-1118*
MI Michigan (313) 525-5850*
MN Minneapolis (612) 559-2211*
MO St. Louis (314) 291-4650*
NC Raleigh (919) 878-9882*
NJ N. New Jersey (201) 882-0320*
Philadelphia (609) 234-9100*
NY Binghamton (607) 798-1611*
Long Island (516) 273-2424*
Rochester (716) 235-7620*
OH Cleveland (216) 248-1788*
Dayton (513) 898-4480*
OR Portland (503) 644-5050*
PA Philadelphia (609) 234-9100*
Pittsburgh (412) 788-0441*
TX Austin (512) 837-1991*
Dallas (214) 233-5200*
El Paso (915) 593-0706*
Houston (713) 895-9200*
San Antonio (512) 734-5100*
UT Salt Lake City (801) 485-1551*
WA Seattle (206) 486-5747*
WI Wisconsin (414) 797-8400*

In Canada: G.S. Marshall Co.
Montreal (514) 694-8142
Ottawa (514) 694-8142*
Toronto (416) 458-8046*

TEXAS INSTRUMENTS
Authorized Distributor

CIRCLE NO. 46

SIEMENS



Third – MKI capacitors

New: metallized polyphenylene sulphide film capacitors with 5-mm lead spacing from Siemens

CIRCLE NO. 51

Siemens MKI capacitors are your best bet when you want constant capacitance, even though other conditions like temperature and humidity show extreme swings. Our small MKI capacitors maintain their rating, whether at – 55°C or + 125°C. These new capacitors show the way to more operating reliability, like in automotive electronics and instrumentation & control.

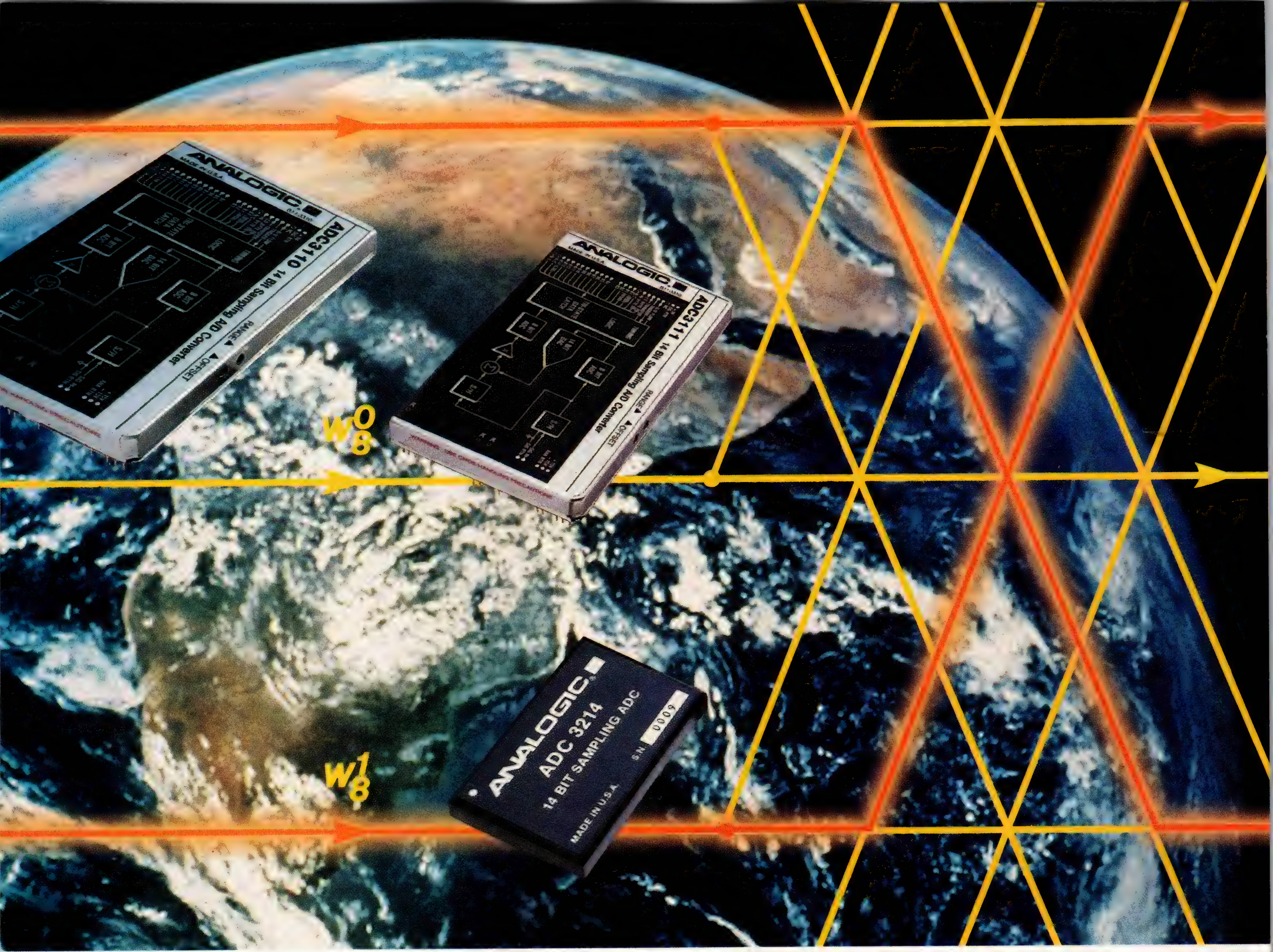
MKI capacitors from Siemens are the successors to the MKC (metallized polycarbonate film) generation. And with their higher capacitance – currently 68 to 330 nF at 50V and 22 to 100 nF at 100V rated voltage – they are a valuable addition to the range of COG ceramic capacitors. Their dissipation factor is convincingly low, and their pulse handling high: stacked-film technology is what counts.

These capacitors come in flame-retardant plastic cases for automatic insertion. And the range will continue to expand for newly emerging applications. To find out more write

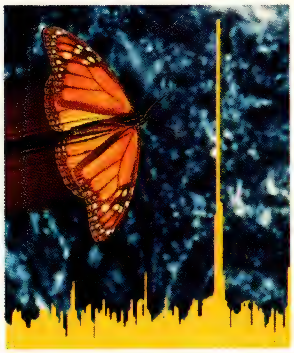
Siemens AG
Group Passive Components
and Electron Tubes, PR VF
Balanstrasse 73
D-8000 Munich 80
West Germany
quoting "MK capacitors".

The components make it – Siemens

A19100-PR102C-X-7600 MC&D



Our A/D's Were Designed to Give You Butterflies*!



True 14-Bit Performance at 1 & 2 MHz Sampling Rates

Analogic's new, ultra stable 14-bit sampling A/D converters make the most of your post-processing computations. Using advanced hybrid and surface mount technology, these sampling A/D's provide the most cost-effective solution to your high speed, high resolution applications.

This new family of sampling A/D's, designed for low noise and low distortion, provides 14 bits of resolution with true 14-bit performance. An 84 dB signal-to-noise ratio and our guarantee of no missing codes over an operating temperature range of 0°C to 60°C make these units unique. The ADC3110 in the frequency domain and the ADC3111 in the time domain will digitize signals up to 1 MHz at a 2 MHz rate, thus achieving unprecedented speed vs. accuracy performance. The ADC3214 has a 1 MHz sampling rate and is packaged as a compact 2" x 3" hybrid.

Our new sampling A/D's will perform superbly in your most demanding OEM applications. Digital oscilloscopes, waveform analysis, high speed data acquisition, sonar and digital signal processors. Whatever your DSP needs, Analogic has a sampling A/D to help you catch the butterflies...*fast*.

We even pledge it in writing. Unlike other manufacturers, Analogic puts all our sampling A/D's through exhaustive tests on our proprietary automatic test systems. The test data shipped with each product is our proof that it meets or exceeds our published specifications. What else would you expect from the world resource for A/D converter technology?

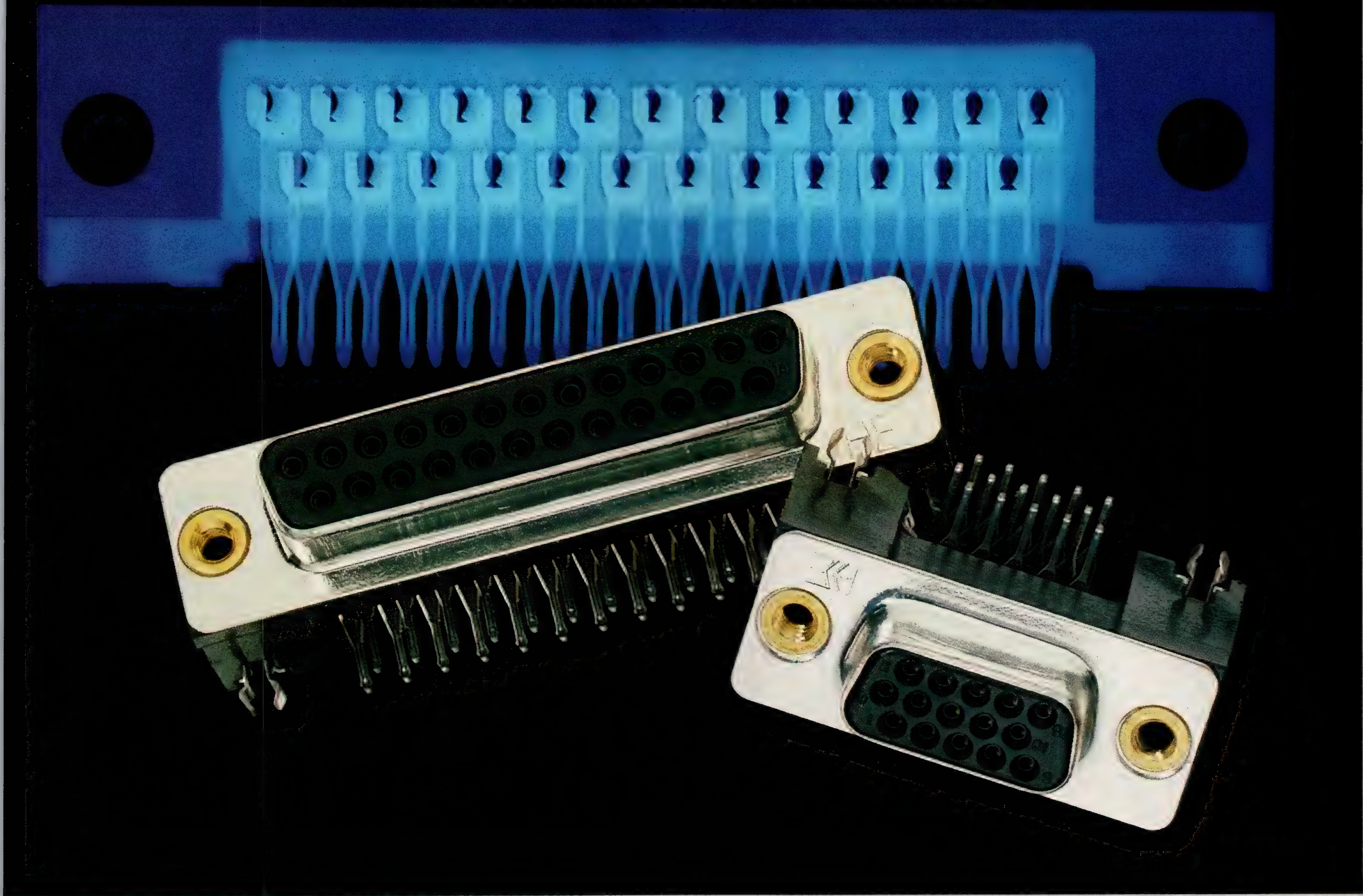
---

* *The illustrated flow graph of the Cooley-Tukey algorithm is known in the industry as a butterfly computation.*

For Application Assistance: Richard Lentini
Analogic Corporation, 360 Audubon Road,
Wakefield, MA 01880 (508) 977-3000 X2170
Telex: 466069, Fax: (617) 245-1274

CIRCLE NO. 45

ANALOGIC®
The World Resource for Precision Signal Technology



X-ray enlargement of 25 position HOLMBERG™ D-Subminiature connector

A new and revealing look at HOLMBERG™ D-Subminiature Connectors.

Quality HOLMBERG™ connectors are now part of the Thomas & Betts product line. We show an X-ray view of one of the HOLMBERG™ D-Subminiature connectors to emphasize that it's what's beneath the surface that makes the difference in a superior product.

Breadth of product line

- The HOLMBERG™ D-Subminiature connector line has one of the widest available varieties of mountings and options — in both standard *and* high density configurations.

Quality from the inside out

- Full vertical integration assures top quality throughout the manufacturing process.
- Extra-rigid and pointed solder tails provide for easier robotic or hand insertion.
- 30 μ-in. selective gold plating in contact mating area is standard.
- Optional snap latches provide positive hold-down.

On time delivery

- Factory and value-added centers provide fast turnaround and strict adherence to customer schedules. A perfect fit for today's Just-In-Time (JIT) manufacturing requirements.

The company behind the product

The addition of HOLMBERG™ connector products further strengthens our position as a broad line supplier of connector products. A close look at our company will reveal our strong financial position, our commitment to the future, and our ability to support your needs worldwide. Write for our Annual Report — it's like an X-ray of our company.

To take a close look at the HOLMBERG™ connector line, and for the location of our nearest stocking distributor, call

1-800-344-4744.

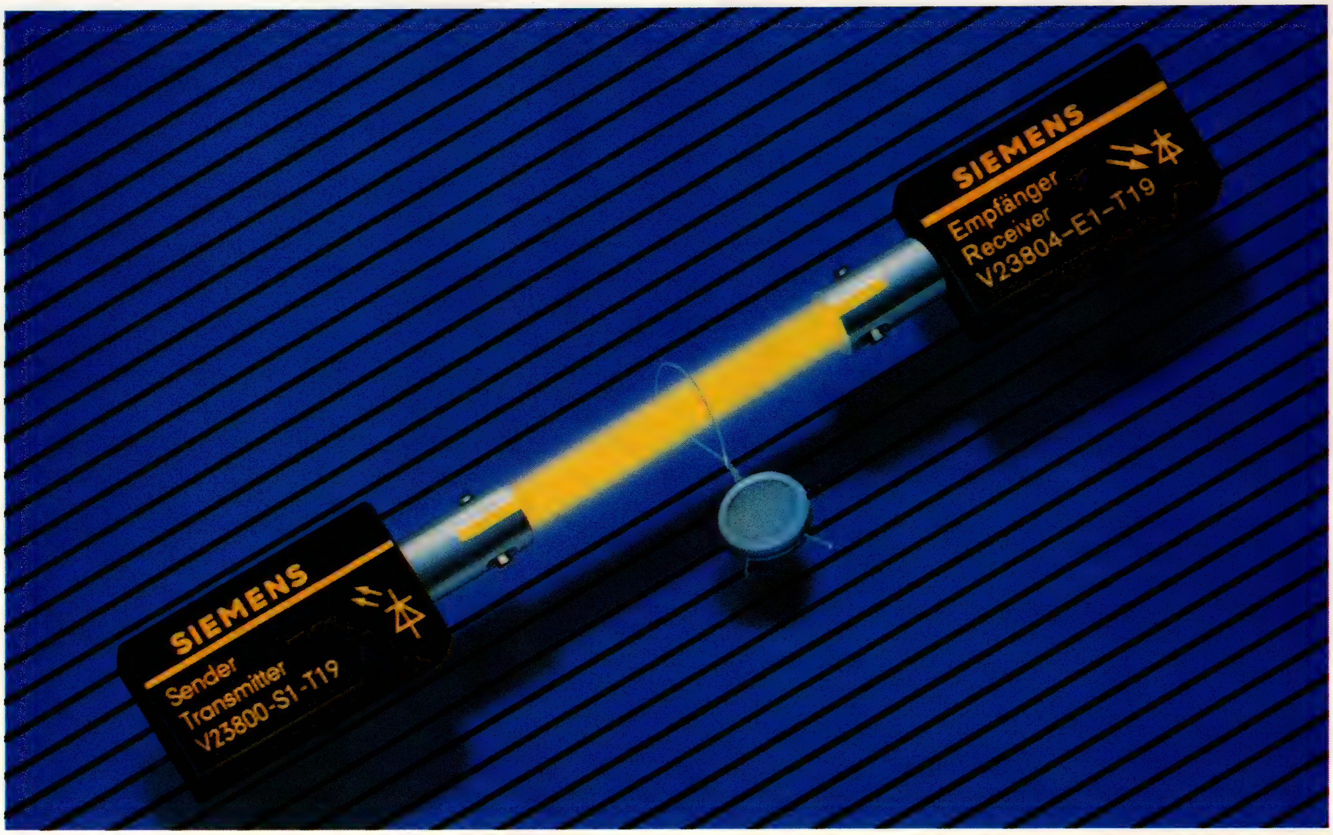
Thomas & Betts Corporation, Electronics Division
1001 Frontier Road, Bridgewater, NJ 08807, 201-685-1600

Thomas&Betts

Thomas & Betts facilities in **Australia:** Wyong North N.S.W., 43 53 2300; **Canada:** Ontario, 416-858-1010; **France:** Rungis Cedex, 1-46 87 23 85; **Hong Kong:** Kowloon, (852) 3-7391286; **Italy:** Milan, 02-61 20 451; **Japan:** Tokyo, 3 791 6411; **Mexico:** Naucalpan, 905 393 85 10; **Singapore:** 747 0244; **Spain:** Barcelona, 03-3 00 22 52; **Sweden:** Upplands Vasby, 07 60-8 81 10; **Taiwan:** Taipei, 2 713 0509; **United Kingdom:** Dunstable 0582-608101; **West Germany:** Egelsbach, 0 61 03-40-40.

SIEMENS

Vital solutions for critical connections in fiber optics



A19100-G4-Z9-X-7600

50 MBaud Data Link from Siemens.

Critical connections demand high reliability. And that requires the experience of a leader in fiber optics. You get both from Siemens, a company that has taken fiber optic technology from R&D to your design bench.

An example of such know-how is our new 50 MBaud transmitter and receiver module, used in data transmission applications ranging from computer tomography to computer aided manufacturing.

Applications where high reliability is mandatory. Where the sensitivity of the receiver is paramount.

Where the distance of transmission demands signal integrity.

Siemens provides such application solutions with its new 50 MBaud components in both TTL and ECL technologies, compatible with either SMA or ST receptacles. They consume little power. And they all include a link-status (signal detect) indicator to monitor operating sensitivity.

We offer a complete family of fiber optic products including FDDI.

For more information...

USA:	(Phone)	1-800-827-3334
	(Fax)	812/4222339
W. Germany:	(Phone)	.30-386-4211
	(Fax)	.30-386-7956

Electromechanical components from Siemens. Quality for sure.

CIRCLE NO. 52

STEPPER MOTORS

Devices handle strict positioning needs

Unlike servo devices, stepper motors can run without feedback control, so they offer a simple means of moving loads precisely and quickly.

Tom Ormond, *Senior Editor*

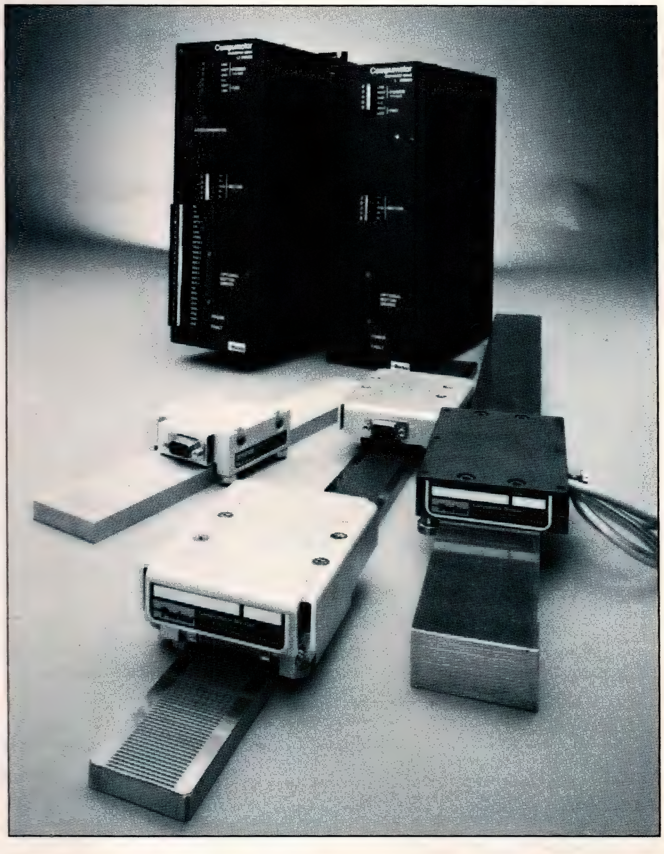
Stepper motors can control shaft speed and position without extra feedback sensors and associated electronics, making them a good choice for applications in which low cost and simple motion control are paramount. Furthermore, steppers are generally very accurate and reliable: Almost every kind of printer, plotter, and chart recorder uses these motors.

The two fundamental types of stepper motors are rotary stepper motors and linear stepper motors. A rotary stepper must translate the shaft's rotation data into linear positioning information, whereas a linear stepper requires no translation.

A rotary stepper motor is an electromechanical device that converts electrical pulses into discrete mechanical motion. This motor has five basic parts: the rotor, stator, bearings, shaft, and housing.

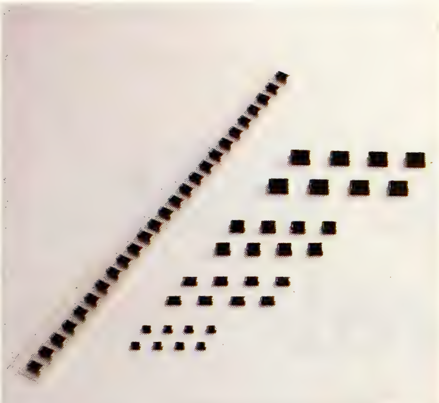
The rotor consists of a permanent magnet that has rare-earth properties; the magnet is located between the top and bottom half of the rotor stacks. Surrounding the permanent magnet is a series of laminations that have teeth on their circumferences. Each tooth creates a natural position for the motor, and the motor maintains a detent position even without the presence of a drive signal.

When the laminations have 200 teeth—or detent positions—on their circumferences, the motor has a 1.8° mechanical step angle. Energizing or deenergizing the motor generates a 0.9° movement. Typically, a lead screw is attached to the motor's shaft and translates the rotary motion into linear motion. When the lead screw has a pitch



To satisfy high-speed needs, *Compumotor's L Series linear stepper motors can operate at velocities in excess of 60 ips. The units offer resolutions from 6000 to 10,000 steps/in.*

TDK Ferrite Technology Blocks out EMI/RFI



Ferrite Chip EMI Suppressor
ACB Series

Ferrite Bead Cores
BB Series

Ferrite Beads
Axial-lead taped type

Ferrite Core for EMI/RFI

For electronic equipment electromagnetic interference is a major concern. That's why so many turn to TDK for assistance. TDK, the ferrite expert has been researching EMI for years. And now, backed by the full complement of TDK ferrite material technology, our products are ready to protect your products from EMI/RFI.

With its phenomenal EMI absorption properties, ferrite was destined to lead the charge against EMI/RFI. And TDK ferrite cores comprise a rich μ_{iac} 45—2700 material composition. They also come in multiple configurations for maximum protection over a wide range of frequencies.

TDK offers you a wide selection of ferrite products from which to choose, ferrite bead cores, chip-type bead cores, a newly developed multi-hole ferrite substrate MH series, and angular cores for flat cables. All are highly effective in eliminating EMI on circuit boards and between interfaces, as well as preventing undesirable signal feedback and interfering oscillation. All of TDK's EMI/RFI products boast high quality materials, and are fabricated according to integrated production processes. Naturally, all of our ferrite products carry the TDK guarantee of reliability, and are suitable for a variety of applications, including advanced computers, automobile electronics, and OA and FA equipment.

If you're ready to fight noise in the electronic environment, it's time you got to know TDK!

For ICs and Connectors
EMI Suppression Multi-hole Substrate

For cables
EMI Suppression Ferrite Cores

Ferrite Toroidal Cores for EMI/RFI Filters

CEL

CEL, TDK's Component Engineering Laboratory in Torrance, CA, is at your service. Phone (213) 530-9397.

TDK Electromagnetic Compatibility Technology—At Your Service!

TDK®

TDK CORPORATION OF AMERICA HEAD OFFICE 1600 Feehanville Drive, Mount Prospect, IL 60056, U.S.A. Phone: (708) 803-6100 CHICAGO REGIONAL OFFICE Phone: (708) 803-6100 INDIANAPOLIS REGIONAL OFFICE Phone: (317) 872-0370 NEW YORK REGIONAL OFFICE Phone: (516) 625-0151 LOS ANGELES REGIONAL OFFICE Phone: (213) 539-6631 DETROIT DISTRICT OFFICE Phone: (313) 353-9393 NEW JERSEY DISTRICT OFFICE Phone: (201) 736-0023 BOSTON DISTRICT OFFICE Phone: (508) 624-4262 HUNTSVILLE DISTRICT OFFICE Phone: (205) 464-0222 GREENSBORO DISTRICT OFFICE Phone: (919) 292-0012 DALLAS DISTRICT OFFICE Phone: (214) 506-9800 SAN FRANCISCO DISTRICT OFFICE Phone: (408) 437-9585 **TDK CORPORATION.** TOKYO, JAPAN.

CIRCLE NO. 54

of 5 threads/in., a 1.8° step is equivalent to a linear motion of 0.001 in.

Today's rotary stepper motors are available with one, two, or three rotor stacks on a single shaft. The number of stacks determines the motor's maximum output-torque capability. A 3-stack motor typically has 2.5 to 3 times the static-torque capability of a 1-stack motor.

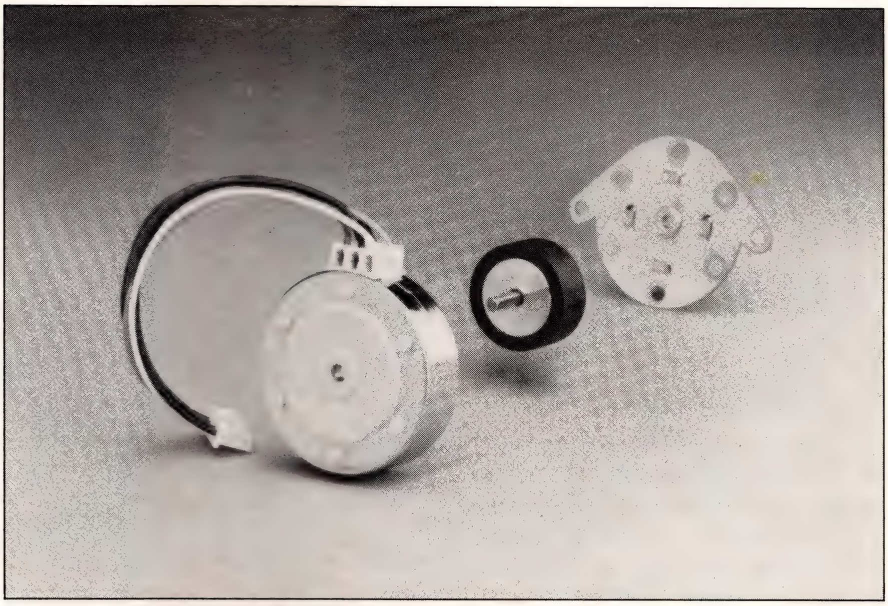
Torque and speed are key parameters in selecting any stepper motor. When you determine the motor's output needs, you must consider the load's friction and inertia components. The motor must overcome load inertia before it can even start to move the load. If the motor has to expend considerable output torque to overcome load inertia, it may not be able to overcome load friction fast enough to meet the application's speed requirements.

The three types of rotary stepper motors are canned-stack stepper motors, variable-reluctance stepper motors, and hybrid stepper motors. Each type offers certain advantages. Canned-stack steppers offer the lowest cost at the expense of high resolution. Variable-reluctance steppers offer higher resolution, and hybrid steppers offer the highest resolution.

Trading precision for low cost

The canned-stack stepper motor is made of stamped parts and is usually the least expensive type of rotary stepper. The stator windings consist of two simple bobbins (components with the lowest possible manufacturing costs), and the rotor is made of molded permanent-magnet material. Stack-type motors are available with 15, 7.5, and 3.75° step angles, so the resolution is poor.

Inland Motors offers a full line of canned-stack stepper motors. The company's PF Series permanent-magnet motors are intended for use in high-volume mass production. The devices are available in a choice of windings and magnet materials (isotropic ferrite, anisotropic ferrite, anisotropic plastic ferrite, and neodymium). This variety lets you match a motor to your specific needs.



***Featuring a modular construction** that increases performance and flexibility, the PM Series motors from NMB Technologies have holding torques of 55 to 1500 g-cm.*

Models in the PF Series are available with step angles of 3.75, 7.5, 15, or 18° and a choice of 20, 24, 48, or 96 steps/revolution. Step-angle tolerance measures ±5%. Various models in the line are also rated for either continuous or intermittent operation.

Holding-torque figures range from 1.11 oz-in. for the PF25-24 Model to 52.8 oz-in. for the PF70-48 Model, which is rated for intermittent operation. The rotor's inertia figures range from 5.36×10^{-3} to 90×10^{-3} oz-in^2. The PF motors feature maximum starting slew rates from 135 pps for the PF70-24 to 1100 pps for the PF25-48. Maximum slew-pulse rates for these models range from 155 pps to 1300 pps.

The PF Series stepper motors operate from single supplies of 5, 12, or 24V. The motors' operating-current requirements range from 67 to 1400 mA/phase, depending on the model and supply voltage. The motors span an operating range of −10 to +50°C. Prices range from $6.17 to $32.21 (1000).

NMB Technologies also offers a line of canned-stack stepper motors. Devices in the Accustep PM Series consist of coils, stator yokes, terminals, and stators molded together by plastic resin. The motors combine this stator piece with rotors that consist of cylindrical permanent magnets. This molded approach yields a motor with better torque and heat-dissipation characteristics than other motors of the same frame size.

Versions in the PM Series offer a choice of 20, 24, 48, 96, or 100 steps/revolution. Holding-torque figures range from 55 to 1500 g-cm, and maximum pull-in frequencies span 370 to 750 pps.

The PM Series stepper motors are available in various face-plate sizes and in 21 standard shaft lengths. The PM Series motors are compatible with either unipolar or bipolar drivers. Housing sizes range 15 to 58 mm. The motors cost from $4 to $5 (5000).

Canned-stack stepper motors perform well in low-resolution applications. However, when system precision is more important than cost, you'll have to go with another technology.

Moving up in precision

Variable-reluctance stepper motors employ a more mature technology and offer higher resolution than canned-stack types. These designs use a rotor, but they have no permanent magnets. Instead, the rotors consist of a steel hub that has serrated parts that function as electromagnetic poles.

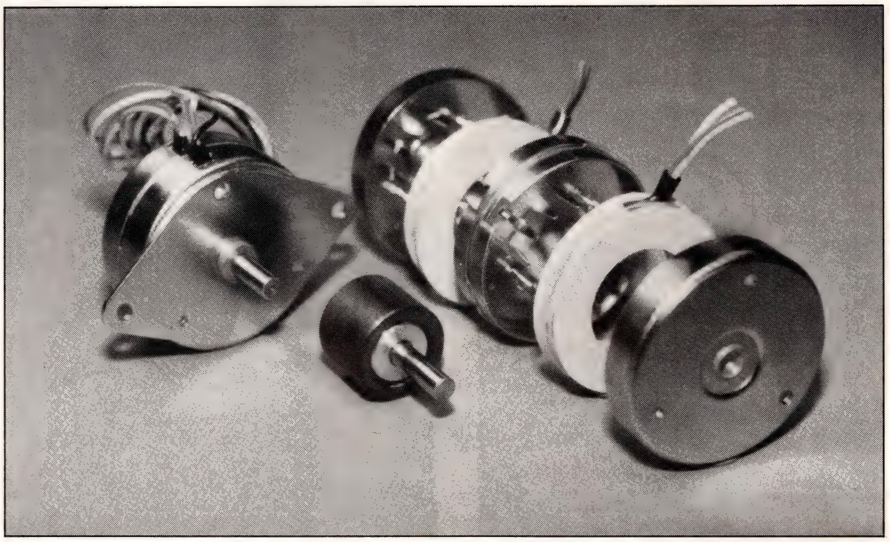
Variable-reluctance stepper motors operate on a principle similar to that of ac-induction motors, but they're different in that they have distinct detent positions that give them their characteristic stepping action.

Because they contain no permanent magnets, variable-reluctance stepper motors have no detent- or cogging-torque parameters. The absence of these two parameters helps the motor operate smoothly. In addition, the absence of permanent magnets makes the variable-reluctance motor a good candidate for low-temperature applications, in which permanent magnets may perform poorly.

Hybrids have highest precision

Hybrid stepper motors are so called because their rotors have both permanent magnets and serrated teeth. This hybrid feature enables them to achieve much higher output torque for a given voltage-current input.

Because the parts are machined rather than stamped, hybrid stepper motors have much better step-angle accuracies—1.8° (200 steps/revolution) is a common, commercially available resolution.



Designed primarily for high-volume applications, *Inland's PF Series motors are available in models that feature step angles of 3.75, 7.5, 15, or 18°.*

Bodine's chopper-rated hybrid stepper motors have a 1.8° step angle and a 3% step accuracy. Available in industry-standard frame sizes of 2.3, 3.4, and 4.2 in., the motors can operate with unipolar, series, and parallel-bipolar drivers. Versions are available with one, two, or three stacks per frame size and with single or dual shafts. To prolong operating life, the motors feature automatic current cutback: after one second at standstill, the motor's phase current automatically drops by 18%.

The Bodine motors have nominal rotor-inertia figures ranging from 1.5 to 110.5×10^{-3} oz-in.-sec^2. Maximum radial load figures range from 15 to 40 lbs; maximum axial load specifications range from 25 to 125 lbs. The static-torque values range from 55 to 1165 oz-in. at full phase-current levels and 45 to 1000 oz-in. at current-cutback levels.

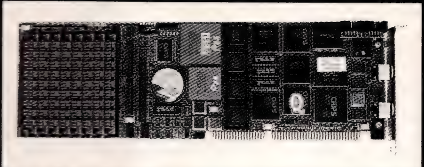
These hybrid stepper motors operate from supply voltages of 36, 40, 48, 72, or 90V. The motors' construction is UL-recognized, and the components carry CSA certification. The windings have UL-recognized, class-F insulation to extend their operating life. Physically and electrically compatible with many competitive motors, Bodine's motors come with eight control leads and an additional wire for grounding provisions. Motor prices range from $35 to $205 in OEM quantities.

In applications involving a dry environment and reasonable temperature and pressure ranges, typical stepper motors operate reliably over extended periods of time. When you introduce harsh environmental factors into the application, however, you instantly increase the complexity of even the simplest positioning systems.

Combustible vapors or dust, for example, make it difficult to automate motion control. It's very difficult to find a stepper motor that can function in a hazardous environment. If a motor doesn't have an explosion-proof rating, it must be isolated from hazardous materials. *Purged and Pressurized Enclosures for Electrical Equipment in Hazardous Locations*, published by the National Fire Protection Association (NFPA), illustrates how to convert the interior of a motor into a nonhazardous area by applying

"386"/AT WORKSTATION "BUILDING BLOCKS" TO THE FUTURE

25MHz "386" w/CACHE SINGLE BOARD COMPUTER



CAT980

This small rugged computer package is the "386" single board performance leader with operating speeds up to 25MHz with CACHE. The entire computer is contained on one /XT form factor card allowing for up to 8 megabytes of onboard RAM. An additional 12 megabytes of RAM can be obtained by the attachment of DTIs "daughter" card directly to the computer. The large amount of onboard 32-bit memory avoids the restrictions encountered in transferring data to conventional add-on memory cards through a 16-bit /AT data bus. See a DTI 1-90 product catalog for a full array of CPU Single Board Computers.

A WIDE VARIETY OF EXPANSION BOARDS FOR "286" & "386" COMPUTERS

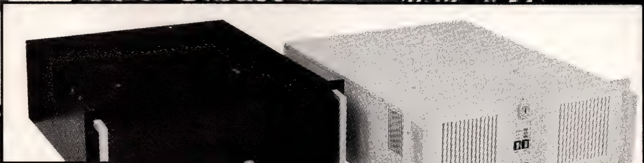
In addition to high performance computers, DTI offers a complete series of expansion boards to perform functions required in the "90s" in most "386" or "286" computers. The chart below depicts the configuration that determines the exact functionality required in the computer application.

NEW

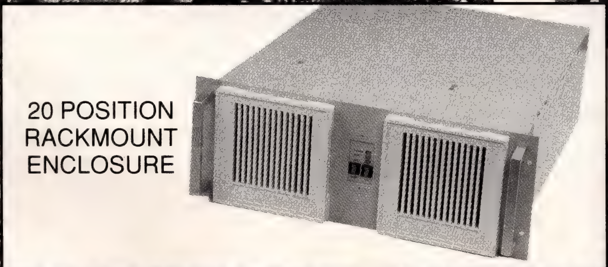
Standard Functons	**Optional Function Descriptions**				
COM1, COM2, LPT1 Floppy Interface IDE Interface	ST506 Interface	SCSI Interface	VGA	Super VGA	Flat Panel VGA
CEX550	No	No	No	No	No
CEX560	Yes	No	No	No	No
CEX561	No	Yes	No	No	No
CEX562	Yes	Yes	No	No	No
CEX570	Yes	No	Yes	No	No
CEX571	No	Yes	Yes	No	No
CEX572	Yes	Yes	Yes	No	No
CEX580	Yes	No	No	Yes	No
CEX581	No	Yes	No	Yes	No
CEX582	Yes	Yes	No	Yes	No
CEX590	Yes	No	No	No	Yes
CEX591	No	Yes	No	No	Yes
CEX592	Yes	Yes	No	No	Yes

INDUSTRIAL ENCLOSURES

10 POSITION RACKMOUNT ENCLOSURE



14 POSITION RACKMOUNT ENCLOSURES



20 POSITION RACKMOUNT ENCLOSURE

1-800-443-2667
(601) 856-4121

Diversified Technology
An ERGON Co.
CIRCLE NO. 55

positive pressure using either dry air or nitrogen.

Empire Magnetics' PT Series stepper motors are equipped with air fittings for pressurization. Using an optional temperature sensor, you can easily design PT Series motors into a system that meets NFPA requirements for Class 1, 2, or 3 hazardous locations.

All PT Series motors are available in frame sizes of 2.3, 3.4, and 4.2 in. Static-torque ratings range from 60 to 1400 oz-in., and thrust-load figures span 25 to 50 lbs. The motors have a 1.8° step angle, a 3% step accuracy, and can accommodate maximum case temperatures of 130°C. Options include 44004-type thermistors (2252Ω at 0°C) and resistance temperature detectors that have a 100Ω resistance at 0°C. prices for the motors range from $834 to $2100.

So far we've discussed rotary stepper motors. The other basic type of stepper motor is the linear stepper motor, also called a linear actuator.

If you need high-speed stepping and your application involves moving a light load, linear stepper motors are your best choice. Microstepped linear-motor systems are also mechanically simple and feature precise, open-loop operating characteristics.

The linear stepper motor doesn't have the linear velocity and acceleration problems that are inherent in systems that convert rotary to linear motion. In a lead-screw-type system, for example, the inertia of the lead screw often exceeds the inertia of the load. When you attempt to execute a high-speed step with a low-mass load, you spend most of the rotary motor's applied torque in overcoming the lead screw's inertia. In addition, the screw's inertia increases as its length increases, which tends to reduce the motor's critical maximum speed. With linear devices, the force generated by the motor is applied directly to the load, and the screw's length has no effect on system inertia.

A linear hybrid stepper operates on the same electromagnetic principles as a rotary hybrid stepper. Linear devices from Compumotor feature a moving element called the forcer and a stationary part called the platen **(Fig 1)** . The platen (or stator) is a passive, serrated steel bar that extends over the desired length of travel. The forcer (or armature) consists of two electromagnets (phase A and phase B) and a strong, rare-earth permanent magnet. The two pole faces of each electromagnet have teeth that concentrate the magnetic flux. Four sets of teeth on the forcer are arranged in spatial quadrature so that only one set at a time will align with the platen teeth.

The magnetic flux passing between the forcer and the platen creates a strong attraction force between the two pieces. When current flows in a field winding, the resulting magnetic field tends to reinforce the permanent magnetic flux at one pole face and cancel it at the other. Reversing the current reverses the cancellation and reinforcement effects. When no current is present, the permanent magnetic flux divides itself equally between

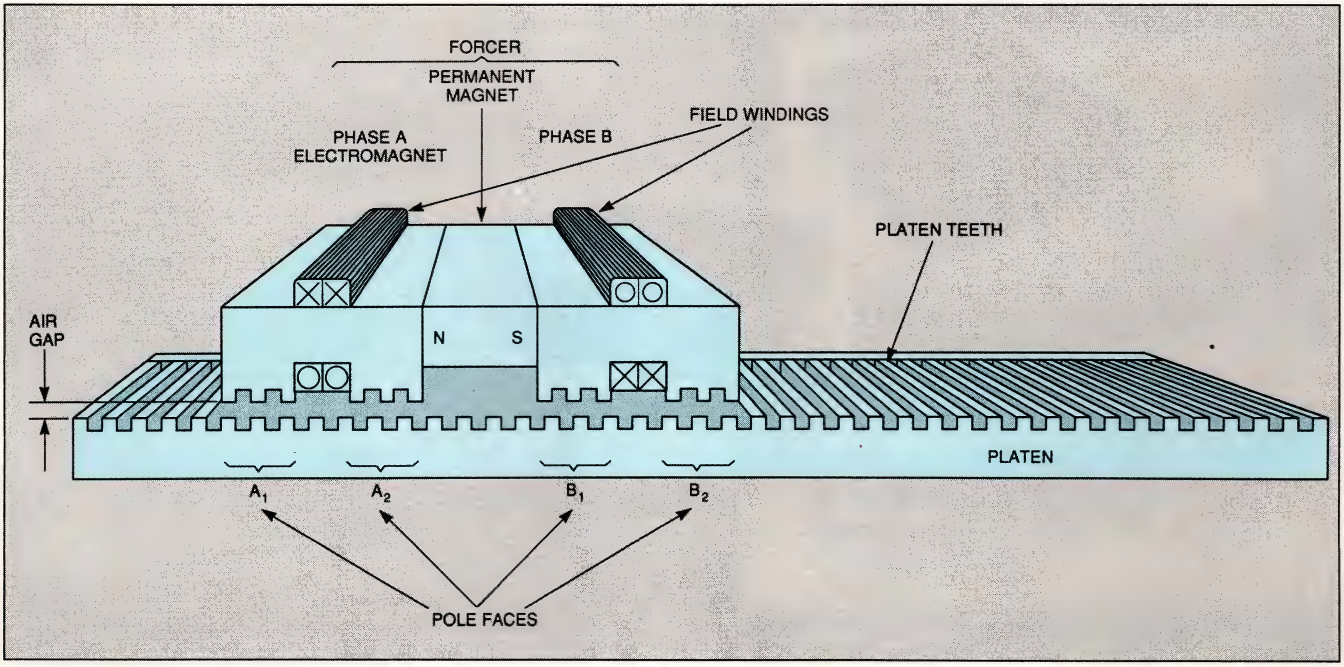
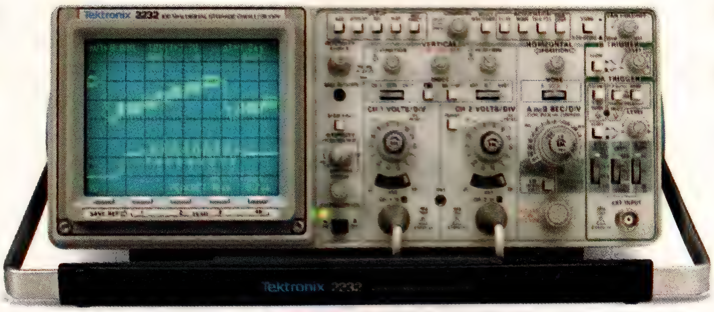


***Fig 1—Linear stepper motors have no inertia problems** because all motor force is applied directly to the load.*

THE CONFIDENCE IT GIVES YOU IS PRICELESS.



When you can't afford to miss a thing, get the new 2232 digital storage oscilloscope from Tek.

The 2232 is a 100 MHz, 100 MS/s digital-plus-analog scope that can detect glitches down to 10 nanoseconds at any sweep speed. As a result, it exposes random events and transient phenomena that elude comparable instruments.

And it's at home in applications ranging from digital-system design to medical equipment service.

You also get features like trigger-level readout, automatic time and voltage measurement, and storage of up to 52 waveform sets—plus a three-year warranty on all parts and labor.

Priceless confidence for only $5495. The new 2232 from Tek.

Confidence at an even lower price.

For outstanding waveform confidence under $2700, look into the new 50 MHz 2211 digital storage oscilloscope.

It combines 20 MS/s digital sampling and analog measurement in one portable, easy-to-use package. And comes with waveform cursors, a 4K record length, horizontal magnification of X10 and X50, a hardcopy interface and much more—all for only $2695.

Confidence is a call away.

To order your 2232 or 2211, or for more information, contact your local Tek representative or distributor. To reach Tek direct,

1-800-426-2200 ext. 200,

or fax a request for information to **(503) 690-3959.**

The free offer is worth up to $340.

EDN031590

Order a Tek 2232 or 2211 DSO between January 15 and May 1, 1990 and you'll receive one of these great items *free!*

☐ **CFG250 2 MHz Function Generator** Produces sine, square and triangle waves plus TTL signals. A $340 value.

☐ **P6062B 1X/10X Switchable Probe** A 100 MHz, 6 ft. probe, list price $190.

To take advantage of our special offer, complete this coupon and return it to your local Tek representative or distributor (be sure to check one of the boxes above). Or, order from Tek direct at **1-800-426-2200, ext. 200** and mention this ad.

Name

Title

Company

Address

City State Zip + 4

( ) Phone Ext.

Application Offer good in U.S. ONLY.

Copyright © Tektronix, Inc. 1989. BOB-080-2

Tektronix®
COMMITTED TO EXCELLENCE

CIRCLE NO. 62

the two pole faces. By judiciously applying current to phases A and B, you can concentrate the flux at any of the forcer's four pole faces. The face with the highest flux concentration will attempt to align its teeth with the platen.

The platen will continue to move as long as you repeat the current sequence. When you stop the sequence, the forcer stops with the appropriate tooth set aligned. At rest, the forcer develops a restoring or holding force, which resists any attempt to displace the forcer from equilibrium. The restoring force will continue to increase until the resting motor's displacement is one-fourth of a tooth interval. Beyond this point, the restoring force drops. If the motor is pushed over the crest of its holding force, the motor will slip or jump and come to rest at an integer number of tooth intervals away from its original location. When the forcer is traveling along the platen, this slippage or jumping is referred to as a stall condition.

Compumotor's linear steppers include three series of motors (the L3C, L5C, and L20 Series) and two lines of controls—the L Series drivers and the LX Series driver/indexers.

The static-force figures for the motors are 3, 6, and 20 lbs for L3C, L5C, and L20 units, respectively. Respective maximum resolutions are 7500, 12,500, and 12,500 microsteps/in. Position repeatability equals 0.0001 in. for L3C and L5C devices and 0.00004 in. for the L20 motors. Standard platen lengths range to 96 in. for L3C and L20 motors and 54 in. for L5C devices. The maximum speeds are 60, 40, and 100 ips for L3C, L5C, and L20 models, respectively.

The L Series motors are available with either mechanical roller bearings (L3C and L5C) or air bearings (L20). Mechanical bearings are simple and have a stiffness that reduces the yaw, pitch, and roll of the forcer. In addition, the friction introduced by the mechanical bearing can reduce the stepper's end-of-move settling time. Because air bearings are free from mechanical friction, they help lengthen the life of the motor. Also, because they can accommodate smaller air gaps, motors with air bearings have more drive capability than those with mechanical bearings. Finally, the moving cushion of air helps clean the platen and also reduces the motor's operating temperature.

The L and LX Series controls are microstepping systems designed specifically for linear steppers. Both systems come in a complete package that includes a power supply, a heat sink, and drive electronics; the LX devices also have an indexer. A Series L3C motor with a 15-in. platen and L Series controls costs $1768, and the same motor with LX Series controls costs $2268.

Airpax offers three lines of linear actuators—Series 92100, 92200, and 92400. All of these bidirectional devices are actually rotary steppers that have been modified by incorporating a preloaded ball bearing and an internally threaded rotor with a lead-screw shaft. Energizing the unit's coils in proper sequence causes the threaded shaft to move out of or into the rotor in linear increments. When the coil power is

For more information . . .

For more information on the stepper-motor products discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

Airpax
Cheshire Div
Cheshire Industrial Park
Cheshire, CT 06410
(203) 271-6000
FAX 203-271-6100
Circle No. 719

Bodine Electric Co
2500 W Bradley Pl
Chicago, IL 60618
(312) 478-3515
FAX 312-478-3232
Circle No. 720

Compumotor Div
Parker Hannifin Corp
1179 N McDowell Blvd
Petaluma, CA 94952
(707) 778-1244
Circle No. 721

Empire Magnetics Inc
Box 1908
Rohnert Park, CA 94928
(707) 584-2801
FAX 707-584-3418
Circle No. 722

Inland Motors
4020 E Inland Rd
Sierra Vista, AZ 85635
(602) 459-1150
FAX 602-458-2161
Circle No. 723

NMB Technologies Inc
9730 Independence Ave
Chatsworth, CA 91311
(818) 341-3355
FAX 818-341-8207
Circle No. 724

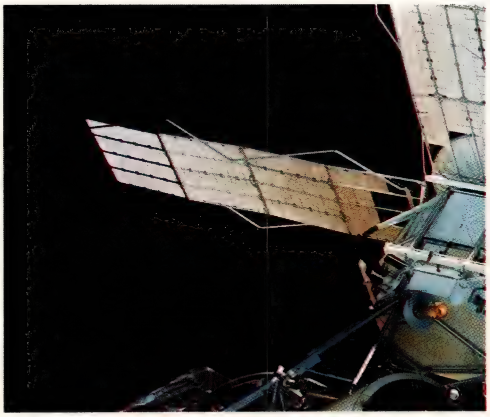
VOTE . . .

Please also use the Information Retrieval Service card to rate this article (circle one):

High Interest 518 **Medium Interest 519** **Low Interest 520**

SPACE QUALIFIED, RAD-HARD CUSTOM CIRCUIT, 14 WEEK DESIGN.

WAS SECRET CRAZY OR WHAT?



Some stories can't be told.

We're going to try anyway and still respect confidentiality.

A major aerospace company wanted a RAD-HARD, space-qualified stepper-driver for positioning the solar array of a highly sensitive military satellite. They wanted fail-safe performance plus adherence to a set of intimidating specs.

And they wanted it fast. "We're in a bit of a hurry," they said.

That was enough for the incumbent. They stepped out of the picture.

Which is just when we stepped in.

You see, few companies in the U.S. can build custom circuits like Silicon General can—quickly, reliably and profitably. That's because in over 20 years of solving problems in silicon, our files are bulging with thousands of IC solutions. We've developed an encyclopedia of circuit design and manufacturing solutions that lead us around the problems and pitfalls that plague less experienced vendors.

We work in partnership with your engineering department through every stage of design and manufacturing and will often assign a full-time project manager to oversee your job, as we did with this customer.

In the case of the stepper-driver, our drop-in replacement not only met form, fit and function, our specs gave the customer a little more latitude to meet his own price/performance requirements.

And to cap it off, we even delivered ahead of schedule.

If you need a partner to design and manufacture power IC's, someone who can meet "impossible" specs and deadlines, remember, nothing is as crazy as it sounds.

Not when you call in the General.

To hear more, contact Silicon General,
11861 Western Avenue, Garden Grove,
CA 92641. TWX: 910-596-1804.
FAX: (714) 893-2570. Phone
(714) 898-8121.

SILICON
GENERAL

Solutions...
that's the general idea.

CIRCLE NO. 56

Vitelic Loads the Bases With Its Cache Lineup.

No outs.
Bases loaded.
What a ballgame!

Vitelic has opened up a commanding lead in the first inning of the 1990 season with its lineup of integrated cache memory products. For those of you who have just tuned in...

On first base is V63C328—Vitelic's cache RAM which optimizes the performance of 20MHz 386SX™ systems. Our 8K x 16, 2-way Set-Associative cache is a **one-chip solution** that increases 386SX performance by more than 30%.

On second base is V63C330—Vitelic's 33MHz cache memory solution that is fully integrated with all 386DX™ cache controllers. The V63C330 is a real scoring threat—designed to support large 64K-128K byte cache.

On third base is V63C430—Vitelic's Rookie-of-the-Year nominee, the latest integrated cache solution. Programmable as either 16K x 16 or 2 x 8K x 16, this high-density cache RAM is designed for 486™ systems up to 40MHz, and is available in 52 pin PLCC.

Call Vitelic today at 800-VITELIC to hear more about the Vitelic team. We've got a ballgame here you don't want to miss.

VITELIC
The Emerging Leader in Specialty Memories

386SX, 386DX and 486 are trademarks of Intel Corporation.

Circle 106 for Literature

Circle 107 for Sales Contact

DID YOU KNOW?

EDN is distributed at every major electronics/computer show in the U.S., France, and Germany.

EDN

Stepper motors

removed, the actuator shaft will remain in position.

Series 92100 actuators are available with linear travel increments of 0.001, 0.002, and 0.004 in./step. All units in the series are available in K versions, which contain an internal antirotational-shaft feature, and in L versions, which require you to handle shaft-rotation problems externally. The actuators' maximum shaft travel is 0.5 in. for the K models and 1.875 in. for L versions. Maximum static-force values range from 16 to 45 oz.

Series 92200 actuators are also available in K and L versions, which have travel increments of 0.001, 0.002, and 0.003 in./step. For K and L versions, the maximum shaft travel is 0.875 and 2.5 in. respectively. Maximum static-force values range from 32 to 75 oz.

Series 92400 actuators, which feature a static-force rating of 16 to 20 lbs, are designed for applications involving heavier loads. Units in this series have a total travel capability of 3 in., moving in linear increments of 0.001 and 0.002 in./step. Series 92400 actuators are available only in L versions. All of the vendor's actuators operate from a single supply of 5 or 12V. The actuators in the three lines range from $6 to $17 in OEM quantities. EDN

Article Interest Quotient
(Circle One)
High 518 Medium 519 Low 520

With this software and your imagination...you can design the most complex circuits from audio to 1,000 MHz using the power of your PC to produce accurate results in no time...leaving your competition behind, at an unbelievable low price.

- User-friendly file editor lets you build circuits fast
- Tweak feature with multiple plotting allows circuits to be fine-tuned in real time
- Complete library of lumped elements ensures versatility
- Industry-standard nodal circuit descriptions and file compatibility with SUPER-COMPACT®
- Microstrip and stripline synthesis
- Bipolar and FET models
- Tolerance analysis
- Unrestricted nodal noise analysis
- User-definable output graphics, including X/Y plots and impedance plots

SUPER-COMPACT RF™ is a fast, powerful design tool for synthesis, analysis and optimization of linear RF Circuits. Easy to use, you'll feel comfortable at the controls, because we've made the operator interface understandable and trouble free, so that building circuit files is a snap. After analysis and optimization, the display menu allows real flexibility in either screen graphics or printer/plotter outputs. All this power won't cost you a bundle either, using your IBM compatible PC operating MS-DOS. And since its roots come from SUPER-COMPACT®, the microwave industry's premier general purpose CAD tool, you know you can rely on our service and support network, regular upgrades and free seminars. Literature and details are yours for the asking.

Compact® Software

The Leader In CAD Software

483 McLean Boulevard, Paterson, New Jersey 07504 • (201) 881-1200 • Fax: (201) 881-8361

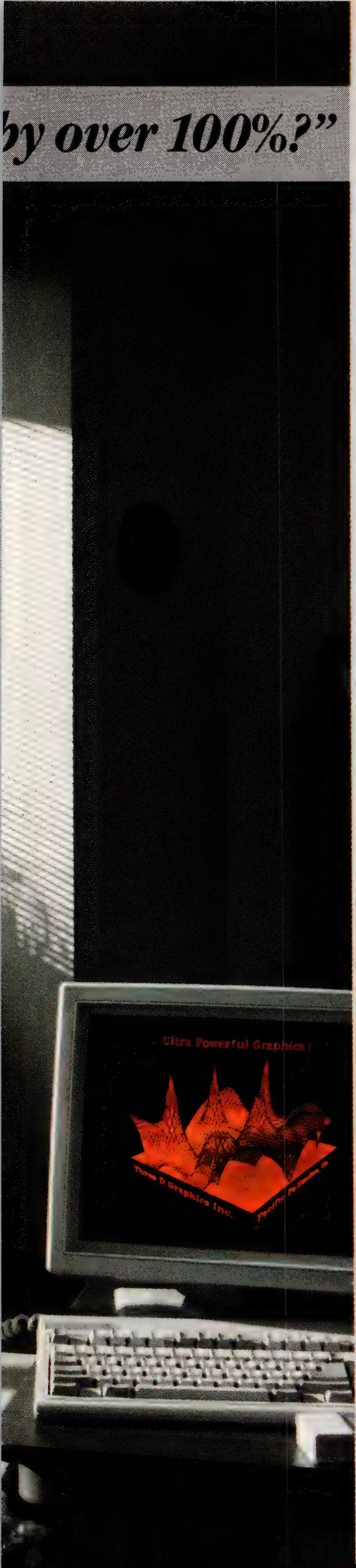
MS-DOS is a trademark of Microsoft® Corporation. IBM is the registered name of International Business Machines.

CIRCLE NO. 57

"Did you know that new 1Mb Video RAMs increase throughput
Assets & Acquisitions [1987]

ALABAMA, Marshall Electronics Group, (205) 881-9235, Milgray Electronics, Inc., (404) 393-9666, Reptron Electronics, (404) 446-1300; **ARKANSAS,** Marshall Electronics Group, (214) 233-5200, Milgray Electronics, Inc., (214) 248-1603, Sterling Electronics-Dallas, (214) 243-1600; **ARIZONA,** Marshall Electronics Group, (602) 496-0290, Sterling Electronics-Phoenix, (602) 268-2121; **CALIFORNIA,** Sterling/Image Electronics, (619) 271-6555, (714) 259-0900, (818) 407-8850, Marshall Electronics Group, (818) 407-0101, (714) 458-5395, (408) 942-4600, (916) 635-9700, (619) 578-9600, Merit Electronics, Inc., (408) 434-0800, Western Microtechnology, (619) 453-8430, (714) 637-0200, (408) 725-1660, (818) 707-0377; **COLORADO,** Marshall Electronics Group, (303) 451-8383, Sterling Electronics-Denver, (303) 792-3939; **CONNECTICUT,** Cronin Electronics, Inc., (203) 265-3134, Marshall Electronics Group, (203) 265-3822, Milgray/Milford (203) 878-5538, Sterling Electronics-Wallingford, (203) 265-9535; **DELAWARE,** General Components, Inc., (609) 768-6767, Marshall Electronics Group, (301) 840-9450, Milgray/Delaware Valley, Inc., (609) 983-5010, (800) 257-7808, (800) 257-7111, Sterling Electronics-Sterling, (703) 450-2373; **DISTRICT OF COLUMBIA,** Marshall Electronics Group, (301) 840-9450, Milgray/Washington, Inc., (301) 621-8169, (800) 638-6656, Sterling Electronics-Sterling, (703) 450-2373; **FLORIDA,** Marshall Electronics Group, (813) 573-1399, (305) 977-4880, (305) 767-8585, Reptron Electronics-Tampa, (813) 855-4656, (305) 735-1112; **GEORGIA,** Marshall Electronics Group, (404) 923-5750, Milgray Electronics, Inc., (404) 446-9777, Reptron, (404) 446-1300; **IDAHO,** Marshall Electronics Group, (801) 485-1551, Western Microtechnology, (503) 629-2082, Milgray Electronics, Inc., (801) 272-4999; **ILLINOIS,** Goold Electronics, (312) 860-7171, Marshall Electronics Group, (312) 490-0155, (314) 291-8554, Milgray Electronics, Inc., (913) 236-8800, (312) 350-0490; **INDIANA,** Goold Electronics, (312) 593-3220, Marshall Electronics Group, (317) 297-0483, Milgray/Chicago, Inc., (312) 350-0490; **IOWA,** Marshall Electronics Group, (612) 559-2211, Milgray Electronics, Inc., (913) 236-8800; **KANSAS,** Marshall Electronics Group, (913) 492-3121, Milgray Electronics, Inc., (913) 236-8800, Sterling Electronics-Kansas, (913) 492-5406; **KENTUCKY,** Marshall Electronics Group, (513) 898-4480, Milgray/Cleveland, Inc., (216) 447-1520, (800) 321-0006; **LOUISIANA,** Marshall Electronics Group, (214) 233-5200, Milgray Electronics, Inc., (214) 248-1603, Sterling Electronics-Dallas, (214) 243-1600; **MAINE,** Cronin Electronics, Inc., (617) 449-5000, Marshall Electronics Group, (617) 658-0810, Sterling Electronics-Boston, (617) 938-6200, Western Microtechnology, (617) 273-2800; **MARYLAND,** Marshall Electronics Group, (301) 622-1118, Sterling Electronics-Sterling, (703) 450-2373; **MASSACHUSETTS,** Cronin Electronics, Inc., (617) 449-5000, Marshall Electronics Group, (617) 658-0810, Sterling Electronics-Boston, (617) 938-6200, Western Microtechnology, (617) 273-2800; **MICHIGAN,** Marshall Electronics Group, (313) 525-5850, Reptron Electronics, Inc., (313) 525-2700; **MINNESOTA,** Marshall Electronics Group, (612) 559-2211, Reptron Electronics, (612) 938-0000, Sterling Electronics, (612) 831-2666; **MISSISSIPPI,** Marshall Electronics Group, (205) 881-9235, Milgray Electronics, Inc., (404) 393-9666; **MISSOURI,** Marshall Electronics Group, (913) 492-3121, (314) 291-8554, Milgray Electronics, Inc., (913) 236-8800, Sterling Electronics/Kansas, (913) 236-5589; **NEBRASKA,** Marshall Electronics Group, (913) 492-3121, Milgray Electronics, Inc., (913) 236-8800, Sterling Electronics-Kansas, (913) 236-5589;

y over 100%?”



SERVICE IS OUR KEY COMPONENT

“1Mb Video RAM?”

“Yeah. With the fancy new Flash Write, Block Write and Split Transfer functions to improve performance.”

“Not bad.”

“And greater density for high resolution color graphics.”

“Come on. We need something we can use today.”

“Toshiba’s got ’em. In quantity.”

First the good news. Toshiba, the leader in 1Mb DRAMs, introduces a new high density 1Mb Video RAM for today’s high resolution color graphic applications.

Now the great news. It’s available in volume production, giving you access to the quantities you need. Today. With capabilities that’ll take you into tomorrow.

Toshiba’s high density, 256K x 4bit and 128K x 8bit Video RAM supports next generation video board or graphic terminal applications by allowing you to store, manipulate and transmit more information than ever before.

	ORGANIZATION		SPECIAL FEATURES				PACKAGE	
	X4	X8	Fast Page Mode	Flash Write	Block Write	Split Transfer	SOJ	ZIP
TC524256A	X		X				X	X
TC524258A	X		X	X	X	X	X	X
TC528126A		X	X				X	
TC528128A		X	X	X	X	X	X	

A multi-port feature combining RAM and SAM gives you easy and fast access to data. Bit Masking is achieved through the Write Per Bit feature.

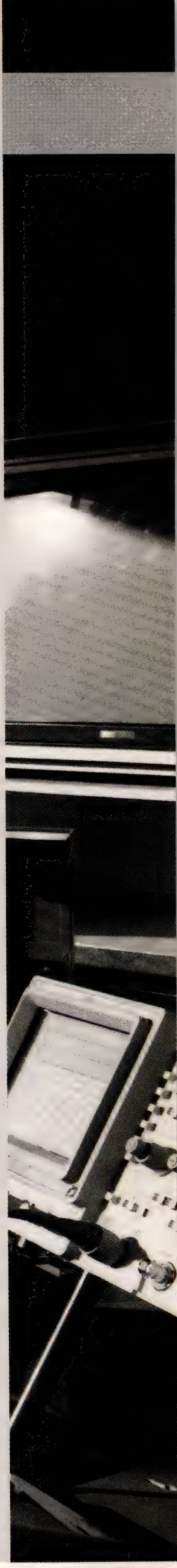
With this feature, selected planes of data can be modified using just a Write cycle instead of a Read-Modify-Write cycle.

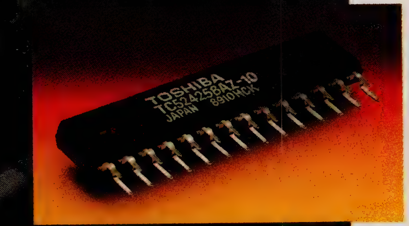
Use the Block Write feature to write four times faster and simplify high speed window clear/fill. Use the Flash Write feature to accomplish high speed clear of selected planes without using the SAM register.

TC524256A/8A & TC528126A/8A	–10	–12
RAS ACCESS TIME (MAX)	100NS	120NS
COLUMN ADDRESS ACCESS TIME (MAX)	30NS	35NS
FAST PAGE MODE CYCLE TIME (MIN)	60NS	70NS
SERIAL ACCESS TIME (MAX)	25NS	35NS
SERIAL CYCLE TIME (MIN)	30NS	40NS

To speed things along even more, RAM read/write cycle times have been improved through fast page mode. A split SAM register provides the best method to simplify SAM to RAM and RAM to SAM transfer timing in the system.

Want more good news? Toshiba’s service is every bit as good as their new Video RAM. With the people and the design specification information you need to get the job done. Call for your complete data sheet today. (1-800-888-0848 ext. 517).





In Touch with Tomorrow

TOSHIBA

TOSHIBA AMERICA ELECTRONIC COMPONENTS, INC.

©1989 Toshiba America, Inc.

MST-88-009

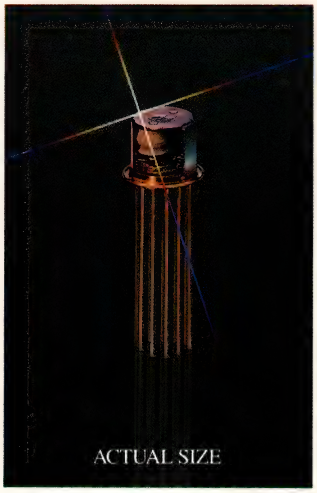
Milgray Electronics, Inc., (913) 236-8800, Sterling Electronics-Kansas, (913) 236-5589; **NEVADA,** Marshall Electronics Group, (916) 635-9700, (602) 496-0290. Sterling Electronics. (602) 268-2121, Western Microtechnology, (408) 725-1660; **NEW HAMPSHIRE,** Cronin Electronics, Inc., (617) 449-5000, Marshall Electronics Group, (617) 658-0810, Sterling Electronics-Boston, (617) 938-6200, Western Microtechnology, (617) 273-2800; **NEW JERSEY,** General Components, Inc., (609) 768-6767. Marshall Electronics Group. (201) 882-0320, (609) 234-9100, Milgray Electronics, Inc., (516) 420-9800, Sterling Electronics-So. Plainfield, (201) 769-7000; **NEW MEXICO,** Marshall Electronics Group, (602) 496-0290, Sterling Electronics-Albuquerque, (505) 884-1900; **NEW YORK,** Marshall Electronics Group, (516) 273-2424, (607) 798-1611, (716) 235-7620. Milgray Electronics, Inc., (516) 420-9800, (716) 235-0830, Rome Electronics, (315) 337-5400; **NORTH/SOUTH CAROLINA,** Marshall Electronics Group, (919) 878-9882, Milgray Electronics, Inc., (404) 393-9666; **NORTH/SOUTH DAKOTA,** Marshall Electronics Group, (612) 559-2211, Reptron Electronics, (612) 938-0000: **OHIO**, Marshall Electronics Group, (513) 898-4480, (216) 248-1788, (614) 891-7580, Milgray/Cleveland, Inc., (216) 447-1520, (800) 321-0006, Reptron Electronics, (614) 436-6675, (216) 349-1415; **OKLAHOMA,** Marshall Electronics Group, (214) 233-5200, Milgray Electronics, Inc., (214) 248-1603, Sterling Electronics-Tulsa. (918) 663-2410: **OREGON**, Marshall Electronics Group, (503) 644-5050, Western Microtechnology, (503) 629-2082; **PENNSYLVANIA,** General Components, Inc., (609) 768-6767, Marshall Electronics Group, (609) 234-9100, (412) 963-0441, Milgray/Cleveland, Inc., (216) 447-1520, (800) 321-0006, Milgray/Delaware Valley, Inc., (609) 983-5010. (800) 257-7808, (800) 257-7111; **RHODE ISLAND,** Cronin Electronics, Inc., (617) 449-5000, Marshall Electronics Group, (617) 658-0810, Sterling Electronics-Boston, (617) 938-6200, Western Microtechnology, (617) 273-2800; **TENNESSEE,** Marshall Electronics Group, (205) 881-9235, Milgray Electronics, Inc., (404) 393-9666: **TEXAS**, Marshall Electronics Group, (214) 233-5200, (915) 593-0706, (713) 895-9200, (512) 837-1991, Milgray Electronics, Inc., (214) 248-1603, Sterling Electronics, (713) 623-6600, (512) 836-1341, (214) 243-1600, Western Microtechnology (214) 248-3775; **UTAH,** Marshall Electronics Group, (801) 485-1551, Sterling Electronics. (801) 972-5498: **VERMONT**, Cronin Electronics, Inc., (617) 449-5000, Marshall Electronics Group. (617) 658-0810, Sterling Electronics-Boston, (617) 938-6200, Western Microtechnology, (617) 273-2800; **VIRGINIA,** Marshall Electronics Group, (301) 840-9450. Milgray/Washington, Inc., (301) 621-8169, (800) 638-6656, Sterling Electronics, (703) 742-8400. (804) 226-2190; **WASHINGTON,** Marshall Electronics Group. (206) 486-5747. Western Microtechnology, (206) 881-6737; **WISCONSIN,** Goold Electronics, (312) 593-3220, Marshall Electronics Group, (414) 797-8400, Milgray/Chicago, Inc., (312) 350-0490, Marsh, (414) 475-6000, Reptron Electronics, (612) 938-0000: **CANADA**, Marshall Electronics Group, (416) 458-8046, ITT Multicomponents. (604) 291-8866. (403) 253-8575, (204) 786-8401, (416) 736-1144, (613) 226-7406, (514) 335-7679, (902) 465-2350, Active Components, (514) 697-8676, (416) 636-8814. (613) 596-5340, (604) 294-1166.

CIRCLE NO. 58

TO-5 RELAY

The Unforgettable Maglatch TO-5

- Non-destructive memory
- Low power consumption
- Inherently bi-stable pulse operation
- CMOS compatible Centigrid® version



The Maglatch TO-5. It's a legend in its own time. The little magnetic latching relay that just won't forget. It can't. Because once you set it with a brief pulse of coil voltage, it simply stays in that state until reset. Even if the system loses power.

In applications where power drain is critical, the Maglatch TO-5 is unbeatable. Since no holding power is needed, it uses less energy than any other type of relay on the market.

The Maglatch's inherently low intercontact capacitance gives it high isolation and low insertion loss up through UHF, making it ideal for RF switching applications. And its tiny footprint makes it ideal for high density printed circuit boards.

The Maglatch TO-5 comes in commercial/industrial versions as well as military versions qualified to "L," "M" and "P" levels of MIL-R-39016. And now it comes in a CMOS compatible version as well. This version can be driven directly with CMOS level signals, with no outside amplification. That cuts down on the number of components and connections, for even greater system reliability.

The Maglatch TO-5. It's the world's smallest relay with indestructible memory. Call or write today for complete information.

TELEDYNE RELAYS
Innovations In Switching Technology

Teledyne Relays, 12525 Daphne Ave., Hawthorne, California 90250 • (213) 777-0077/**European Headquarters**: W. Germany: Abraham Lincoln Strasse 38-42, 6200 Wiesbaden/Belgium: 181 Chaussee de la Hulpe, 1170 Brussels/U.K.: The Harlequin Centre, Southall Lane, Southall, Middlesex, UB2 5NH/ Japan: Taikoh No. 3 Building, 2-10-7 Shibuya, Shibuya-Ku, Tokyo 150/France: 85-87 Rue Anatole-France, 92300 Levallois-Perret.

A PERSPECTIVE ON ASIC DESIGN

"At Texas Instruments, you have the choices you need to get the ASIC you need. That's the difference between an ASIC device and an ASIC solution."

"An ASIC solution is more than a choice of silicon. To keep you from compromising on a square peg for a round hole, an ASIC solution involves many considerations: Your performance needs. How much control you want to exercise. The amount of support you require. What you can spend. How narrow your market window is. It's the result of you and your supplier weighing all the choices and reaching a balanced decision. At Texas Instruments, that's the way we like to work.

"A solution should not limit you to 'classic' ASICs — gate arrays and standard cells. That's why TI includes user programmables in its ASIC lineup. We manufacture high-performance, programmable logic devices (PLDs) and high-density, field-programmable gate arrays (FPGAs).

"Such a broad choice allows you to make better value judgments about control, NRE investment, and cycle times.

"TI advocates open-system CAD architectures instead of confining you to proprietary CAD systems. We support both PC- and workstation-based design systems.

"We provide as much advice and counsel as you need or want just about anywhere in the world. Our documentation is so comprehensive it can fill your bookcase as it fills your needs.

"We are looking to future solutions. For example, we are developing submicron CMOS and BiCMOS gate arrays and standard cells with densities over 100K gates. We are extending our support by developing software that migrates FPGA designs to mask-programmed gate arrays.

"An ASIC solution also brings with it assurances of the supplier's dependability, stability, and capability to produce and deliver.

"At TI, we invite you to experience the difference between compromise and choice — the difference between an ASIC device and an ASIC solution."

Wally Rhines

Walden C. Rhines, Ph.D.
Executive Vice President, Semiconductor Group
Texas Instruments Incorporated

At TI, we cover your ASIC needs from silicon to software to service and support.

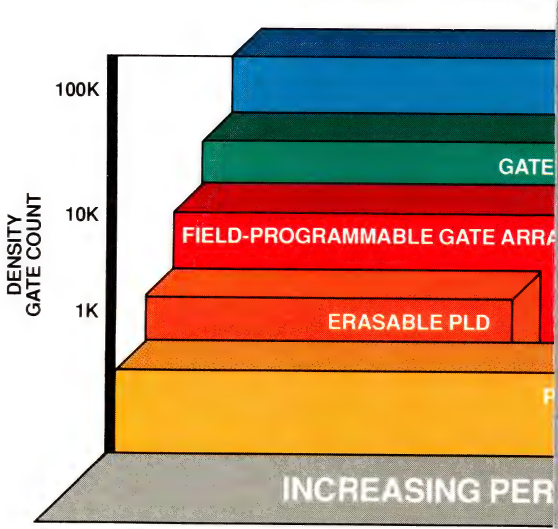
Few ASIC suppliers match TI's breadth of choice and depth of support in helping you develop the most efficient round peg for a round hole. As you see below, our ASIC family spans the architectural spectrum from PLDs to standard cells.

PLDs: High performance, low risk

PLDs are a low-risk, affordable design solution for high-speed-logic consolidation. Stocked on TI distributors' shelves, they allow a quick ramp to volume production.

TI offers more than 40 PLD functions in industry-standard architectures, including the high-speed, 7.5-ns TIBPAL16XX-7 and TIBPAL20XX-7. For high-performance applications, TI also offers unique functions such as the programmable sequence generator, TIBPSG507, and one of industry's fastest programmable address decoders, the 6-ns TIBPAL18N8-6.

TI's ASIC PRODUC



Programming is quick and easy using readily available, third-party design software and programming hardware. For your high-volume production requirements, programming and testing services are available both from TI and authorized distributors.

When low power and reprogrammability are important, an erasable PLD (EPLD) gives you the freedom to make design changes quickly and easily. For high-volume production requirements, EPLDs are also available in one-time-programmable plastic packages.

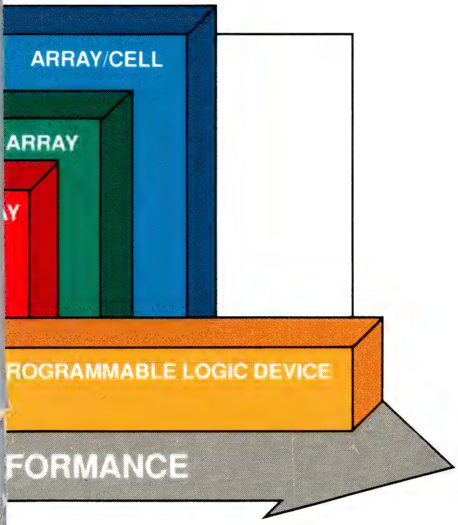
To move your EPLD design rapidly from concept to silicon, the TI EPLD Development System accepts a variety of entry formats. These include schematic capture, Boolean equations, state-machine diagrams, and truth tables. TI's desktop CAE tool runs on an IBM®-compatible PC-AT™.

FPGAs: Best of two worlds

Like PLDs, FPGAs are user programmable, provide rapid design and debug, are simple to use, and are virtually risk-free. Like masked gate arrays, FPGAs feature high gate densities, high performance, a large number of user-definable I/Os, and a gate array-like design environment.

Currently available are TI's TPC1010A (1200 gates) and the TPC1020A (2000), with higher densities to follow. Unlike PLDs and gate arrays, FPGAs have a unique architecture that allows 100% observability of the internal circuitry. This provides flexibility of design verification, either "in-circuit" or "in the programming box."

T SPECTRUM



The TI Action Logic System (TI-ALS) is a powerful development tool for implementing your FPGA designs while avoiding NRE fees. The TI-ALS accepts designs from popular CAE software packages including Viewlogic™, OrCAD™, Mentor Graphics™, and Valid™ — resident on PC386, Apollo™, and Sun-3™ platforms.

Gate arrays for greater differentiation

For applications requiring higher-density, high-performance ASICs with fast prototype delivery, TI's TGC100 Series 1-micron gate arrays are an excellent choice. Offering gate-array complexities up to 26K gates and 256 I/Os, the TGC100 Series utilizes familiar general-purpose logic libraries. You can define macros and pinouts, as well as specify packages with pin counts up to 256 pins.

A comprehensive design kit provides the information you need to easily implement your gate-array design.

ASIC design centers, located at TI's Regional Technology Centers, are staffed with design specialists who are ready to help you.

Standard cells: As specific, as complex as you need

For ultimate performance and system integration, TI's TSC500 Series is your choice. The extensive cell library contains high-performance memory, register files, FIFOs, and MegaModule™ building blocks. Realizing the need to incorporate design-for-test into today's high-density ASICs, TI also includes JTAG-compatible SCOPE™ testability cells in its library.

Thus, you can tailor a standard-cell design to meet your exact system requirements. As with our gate arrays, a design kit is available, as well as technical design assistance through TI's ASIC design centers.

For details about the support and service TI offers, please turn the page.

> **“I need a high-spe part with unique functionality. Standar architecture is a big priority, too. Plus, I’ going into production and need volume delivery now.”**

The TI Solution:

Programmable Log Devices

TEXAS INSTRUMENTS

A PERSPECTIVE ON DESIGN ISSUES:

ASICs – Choice not compromise

IN THE ERA OF

MegaChip

TECHNOLOGIES

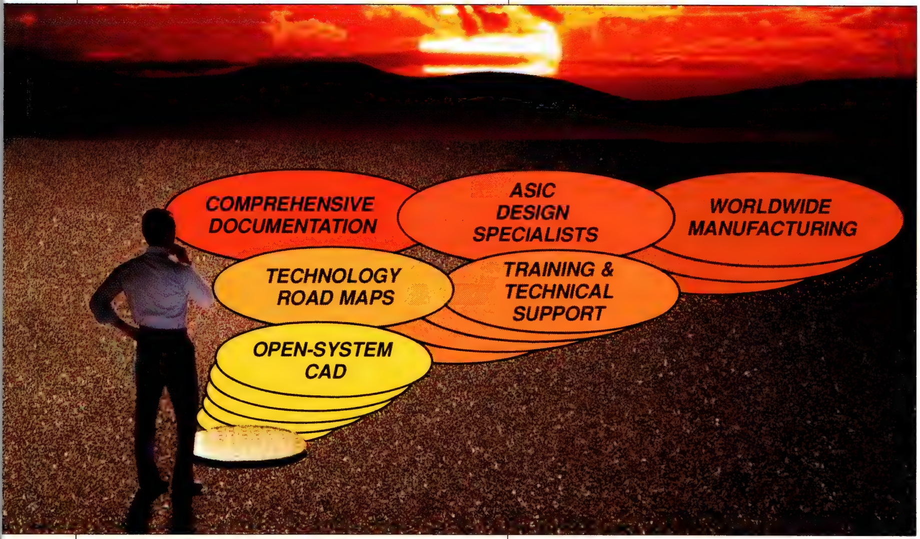
A PERSPECTIVE ON ASIC DESIGN

The sun never sets on TI's service and support.

That's literally true. We have facilities and sites around the world. From early in your design cycle until you have the ASIC solution you envision, TI support and service are available wherever you are.

This around-the-world service and support include that which you have come to expect from TI: Comprehensive documentation and technical literature. Workshop training at our Regional Technology Centers. ASIC design and applications specialists to provide one-on-one advice and counsel. Development hardware and software.

Our design flow is straightforward and minimizes the possibility of surprises.



Our worldwide wafer-fabrication capability is unmatched and moving into the submicron era. We have disclosed a 106K gate array fabricated with our EPIC™-II, 0.8-micron BiCMOS process technology.

Such extensive service and support satisfy the majority of our customers' requirements, resulting in round pegs for round holes. But what if you are one of those whose ASIC solution must be a peg of unusual shape?

Tailoring the "fit"

In these special instances, we will tailor our procedures to your needs, striving to be as "application specific" as the term implies.

For example, certain business issues become very important when a programmable ASIC is best for you. Here, rapidly changing market conditions require absolute supplier dependability.

We can work with you to maintain your inventory levels. We can adapt our production to support your ship-to-stock or just-in-time programs. And if you'd like, we can deliver programmed or unprogrammed PLDs and other ASICs symbolized to your specifications to reduce your internal handling.

We are well aware that an ASIC solution is more than silicon, more than standard service and support.

You may want us to analyze your evolving ASIC designs and needs with you in relation to our evolving technologies. We can "tweak" our design flow to suit your requirements and integrate our design tools within your proprietary CAD systems when required. If your design calls for a proprietary function, we can also create a custom cell to suit your needs.

TI's MegaChip™ Technologies are the means by which we can help you and your company get to market faster with better, more competitive products. Our emphasis on volume manufacturing of high-density circuits is the catalyst for ongoing advances in how we design, process, and manufacture semiconductors and in how we serve our customers.

We at TI are willing to go the extra mile in service and support in order to achieve the ASIC solution best for you.

For more information on TI ASICs, call, fax, or write us. **In Europe** call 44-234-223000, fax 44-234-223459, or write Customer Response Centre, MS 09, Texas Instruments Limited, Manton Lane, Bedford MK41 7PA, England. **In Japan** call 81-769-8700, fax 81-457-6777, or write Texas Instruments Japan Limited, MS Shibaura Building 9F, 4-13-23 Shibaura, Minato-Ku, Tokyo 108, Japan. **In Hong Kong** call 852-735-1223, fax 852-735-4954, or write Texas Instruments Hong Kong Limited, Market Communications Department, 8th Floor World Shipping Centre, 7 Canton Road, Kowloon, Hong Kong.

™ MegaModule, SCOPE, EPIC, and MegaChip are trademarks of Texas Instruments Incorporated.
PC-AT is a trademark of International Business Machines Corporation.
Viewlogic is a trademark of Viewlogic Systems, Inc.
OrCAD is a trademark of OrCAD Systems Corporation.
Mentor Graphics is a trademark of Mentor Graphics Coporation.
Valid is a trademark of Valid Logic Corporation
Apollo is a trademark of Apollo Computer Inc.
Sun-3 is a trademark of Sun Microsystems, Inc.
® IBM is a registered trademark of International Business Machines Corporation.

© 1990 TI 08-9338B

TEXAS INSTRUMENTS

IN THE ERA OF MEGACHIP TECHNOLOGIES

On my schedule,
ivery delays and
necessary risks are
t. Our design
juires the density of
ate array, but we
ed to handle all the
ogrammation
rselves.”

TI Solution:

ield-Programmable
Gate Arrays

“The system my team is designing calls for a high-density, high-performance ASIC. I want to call the shots on pin count, pinout definition, and the package itself. Fast prototype cycle time, JIT delivery, and low cost are mandatory.”

The TI Solution:

Gate Arrays

“We are developing a unique product that requires high-speed memory and other complex functions integrated on the same chip. Surface-mount, high-pin-count packaging is a major requirement.”

The TI Solution:

Standard Cells

MICROCONTROLLER DEVELOPMENT SYSTEMS

Advances simplify μC design tasks

How much development time and effort will you save by spending more on development tools?

J D Mosley,
Regional Editor

The prices of 8-bit microcontrollers (μCs) are plunging, but the cost of development systems for these devices range from Allen Systems' $250 CP-31 single-board-computer/EPROM debugger to Quickturn Systems' $125,000 RPM multipurpose omniemulation mainframe, which you can also use to verify 100,000-gate ASIC designs. In fact, for the truly intrepid (or the incredibly frugal), Allen Systems will sell you a bare CP-31 board with a user's manual for $75. At the other end of the price spectrum, the RPM requires you to develop a software rendition of your target μC before you can even begin to emulate its operation for in-circuit emulation. But for design situations in which you have an ASIC with a μC core, the RPM's sea-of-gates simulation system may indeed provide the most effective design and verification system for your project.

For a base price of just under $10,000, *you can purchase an interactive, plug-and-go mainframe system that specifically suits the idiosyncrasies of a particular μC. This development system from Texas Instruments provides a comprehensive set of tools for emulating its TMS370.*

For most μC development tasks, the most efficient and cost-effective tools come in an assortment of hardware and software products that sell for $1000 to $10,000. If you prefer the efficiency of programming with assembler, you'll find that the development systems priced at $1000 to $4000 include an assortment of software tools that let you focus on the creative aspects of your coding task.

If you aren't comfortable with assembly language, you can take advantage of the flood of $4000 to $10,000 development tools that provide support for programming with higher-level languages such as C or PL/M. If you prefer programming in Pascal, Huntsville Microsystems offers a $1500 debugger for its family of in-circuit emulators, which lets you view only the source code, the source code with the generated assembly code, or just the assembly code.

Examine the software features

The hardware in μC development systems is fairly well standardized, so most manufacturers attempt to differentiate their development tools on the merits of their software. The companies that offer C compilers for their systems assert that using such a high-level language permits you to concentrate on your programming objectives rather than forcing you to perform tedious housekeeping duties, such as keeping track of the state of your μC's registers.

Once you've completed your C program, the development system's compiler converts your code into machine code. Accordingly, the generated machine code must be compact enough to fit into the small memory areas that you so frequently find in μCs. Keep in mind that not all compilers are equally efficient at compacting high-level language into machine code.

Although several systems support languages other than C, you'll find that C is widely offered, partly because it's a portable language with ANSI standardization (X3.159). Yet, you should note that few μCs match the architecture of the computer that C was developed for. Therefore, C compilers for μCs often have nonstandard, nonportable "extensions" to handle each μC's hardware peculiarities.

Generally, though, C is well known for its organized structure and ease of maintenance—important features if your company intends to develop future generations of your end-product. When compared with assembler code, C is typically easier to read, interpret, and maintain—even if another programmer wrote the code.

Table 1—Representative 8-bit microcontroller development systems

Manufacturer	Model	μC family	Host computer	Base price	In-circuit emulator
Allen Systems	CP-31	8051	IBM PC and compatibles	$250	
	FX-11	68HC11	IBM PC and compatibles	$375	
Ashling Microsystems Ltd	CT851	8052	IBM PC and compatibles	$4950	•
	CT68HC11	MC68HC11	IBM PC and compatibles	$5950	•
Fujitsu Microelectronics	MB2125	MB89710	IBM PC and compatibles	$6000	$4540
Harris Semiconductor	CDP68EM05C4	6805	Piggyback emulator	$60	•
Huntsville Microsystems	HMI-200-6809	6809/6809E	IBM PC/AT; PS/2; Sun; Apollo	$4995	•
	HMI-200-68HC11	68HC11	IBM PC/AT; PS/2; Sun; Apollo	$4995	•
	HMI-200-8051	8051	IBM PC/AT; PS/2; Sun; Apollo	$4995	•
Macrochip Research	MR68HC05	MC68HC05	IBM PC/AT and compatibles	$2495	•
	MR320C14	TMS320E14	IBM PC/AT and compatibles; Apple Macintosh; Commodore Amiga	$1995	•
	MR370	TMS370CXXX	IBM PC/AT and compatibles; Apple Macintosh; Commodore Amiga	$1795	•
	MR7180X	HD647180X	IBM PC/AT and compatibles; Apple Macintosh; Commodore Amiga	$1995	•
MetaLink Corp	MetaICE	83C451, 83C152, 80515, 80512	IBM PC and compatibles; IBM PS/2	$4295	•
	MetaICE+	8051	IBM PC and compatibles; IBM PS/2	$2099	•
Mitsubishi Electronics America	PC4000	Series 740 and 7450	IBM PC/AT and compatibles	$1100	$1000 to $3000
National Semiconductor	COP8-MOLE-PB1	COP820, COP840, COP8620, COP8640, COP8720	IBM PC and compatibles	$4590	•
	HPC-DEV-SYS-400E	HPC16400E	IBM PC and compatibles; VAX-VMS	$8750	•
OKI Semiconductor	EASE80C51MK2	80C51/31, 83C154, 80C154	IBM PC/AT and compatibles	$7000	
	EASE 66301	MSM 66301	IBM PC/AT and compatibles	$10,000	
SGS-Thomson	TSTIN48-1/TSTMUP4D	ST61XX	IBM PC and compatibles	$6000	•
	EMST62-HW/XX	ST62XX	IBM PC and compatibles	$6500	•
	ST90XX-HDS/110	ST90XX	IBM PC and compatibles	$6500	•
Signum Systems	USP-51	8051	IBM PC and compatibles; any RS-232C host	$4700	•
	E232-DSP17	320C17, 320E17	IBM PC and compatibles; any RS-232C host	$6900	•
Softaid Inc	647180X IceAlyzer	647180X	IBM PC and compatibles; terminals	$5995	•
Sophia Systems	SA98-8051/52/54	8051/52/54	IBM PC and compatibles	$7800	•
	SA98-M37450	M37450	IBM PC and compatibles	$9300	•
Texas Instruments	TMS370 Development System	TMS370	IBM PC and compatibles; DEC VAX; Apple Macintosh	$9500	XDS/22 ($8250); XDS/11 ($2850)
	TMS7000 CMOS XDS/22	TMS7000	IBM PC and compatibles; DEC VAX	$5900	•

Note: N/A = Not applicable.

However, because you must still maintain control over the final object code as well as your C source code, Softaid sells an optional source-level debugger that displays the original source code positioned at a current program-counter address. This debugger is an important feature because there is often no obvious correlation between the compiled code and your original C source code. Emulators only provide you with the target system's disassembled code, which may not be particularly useful to C programmers.

For its $7940 EZ-Pro development system, American Automation offers a C compiler that lets you mix and debug assembler and C in the same program or link C and assembly-language modules to create a uniform program. The EZ-Pro display comprises multiple windows that provide separate areas for variables, I/O requests, register states, and stack information. Included with the company's $2495 AA542 performance analyzer is Show-Tyme, a software package that lets you measure the runtime performance of your source code. The performance analyzer displays its results in a graphical format whose histograms illustrate the timing distribution and spatial activity of subroutines you have specified.

You can request a copy of EZ-

Emulator speed	Buffer size	Cross compilers	Cross assembler	Linker	Archiver	Code converters	Debugger	EPROM programmer	EEPROM programmer	Real-time capabilities
N/A	N/A	N/A	$100				$35 to $100			Emulation
N/A	N/A	N/A	$100							Emulation
16 MHz	N/A	Pathfinder C, PL/M-51	$495	•		•	•	$733	$941	Emulation
16 MHz	N/A	Pathfinder C	$495	•		•	•	$733	$288	Emulation
12 MHz	192k bytes	C	•	•	•	•	•	•		Trace, trigger, emulation
10 MHz	176 bytes	N/A	N/A							Emulation
8 MHz	4k×72 bits (2)	C	$300	•		•	$500 to $1500			Emulation
8 MHz	4k×88 bits (2)	C	N/A			•	$500 to $1500			Emulation
8 MHz	4k×88 bits (2)	C, PL/M	$300	•		•	$500 to $1500			Emulation
4 MHz	2k bytes (trace)	N/A	•				•	•	•	Emulation, breakpoints, trigger
25 MHz	N/A	N/A	•				•			Emulation, breakpoints, trigger
20 MHz	N/A	N/A	•				•		•	Emulation, breakpoints, trigger
10 MHz	N/A	N/A	•				•	$250		Emulation, breakpoints, trigger
16 MHz	4k bytes	N/A	$200							Emulation
16 MHz	2k bytes	N/A	$200					$399		Emulation
12 MHz	64k bytes	N/A	$400	•			$450			Trace
20 MHz	8k bytes	N/A	$250					•	•	Trace, breakpoints, emulation
20 MHz	64k bytes	ANSI C	$495	•	•		$950	•		Emulation
N/A	N/A	N/A	$700	•	•	•	•	•		Breakpoints, trace, trigger
N/A	N/A	N/A	•	•	•	•	•			Breakpoints, trace, trigger
8 MHz	4k bytes	N/A	$500				•	•		Trace
8 MHz	16k bytes	N/A	•	•			•	•	•	Trace
24 MHz	128k bytes	C	•	•	•		•	$350	•	Trace
25 MHz	32k×80 bits (trace)	C, PL/M-51	$200	•			•			Trace, breakpoints, emulation, code substitution
25 MHz	32k×80 bits (trace)	N/A	$200 to $595	•			•			Trace, breakpoints, emulation
8 MHz	2k bytes	N/A	N/A				•			Emulation, trace, breakpoints
16 MHz	2k bytes	C	$500				•			Trace, breakpoints, emulation
10 MHz	2k bytes	C	$500				•			Trace, breakpoints, emulation
20 MHz	64k bytes	N/A	$550 (PC/MS-DOS); $1000 (VAX VMS)	•	•	•	•	$1250 (Includes EEPROM programmer)	$1250 (Includes EPROM programmer)	Trace, breakpoints, emulation
20 MHz	64k bytes	N/A	$300 (PC/MS-DOS); $500 (VAX VMS)	•	•	•	•			Trace, breakpoints, emulation

Demo—an interactive simulation of the EZ-Pro system—from American Automation. The company also offers TeleBench, a free service that lets you submit samples of source code for compiling and assembling. You can use the resulting code to help you select a chip. Another service, TelePresence/Demo, lets you access an EZ-Pro system via a modem and try out the company's TelePresence remote diagnostic software.

Most in-circuit emulators *cost between $2000 and $5000 and rely on your host computer for software storage and processing power.*

Do what I meant

Sophia Systems offers some unique features in its development systems, including what the company calls "DWIM" (Do What I Meant) commands. For example, Break and Stop commands produce the same effect, and you can similarly use Go and Run interchangeably. The company also provides a parallel interface between your PC and the development system to maximize PC-bus transfer rates. This parallel interface speeds data faster than the serial links that other systems have. The systems also have on-line help and a direct-access controller interface that lets you manipulate target RAM or I/O—even when the target program is executing. An optional performance-analysis card generates an execution-address map and provides a time and address analysis of execution performance.

The PathFinder source-level debugger that comes with Ashling Microsystems' in-circuit emulator automatically synchronizes the contents of the source language debug window that it displays. As you move your cursor through the disassembled-memory window or the traced-I/O-activity window, PathFinder finds and displays the relevant source code and address-bus activity. PathFinder also automatically calculates the location of variables within multidimensional arrays and complex data structures. In addition, this debugger provides a user-definable DOS shell facility that lets you browse through external DOS files and allocate as much as 500k bytes of the development system's RAM for integrating your editing, compiling, and linking tasks.

It makes sense that the company that created the μC you've selected

Table 2—Representative 8-bit microcontroller development software

Company	Model	μC family	Host computer	Base price	Cross compiler	Cross assembler	Linker	Archiver	Code converter	Debugger
Archimedes Software	C-6801/6803	6801; 6803	IBM PC and compatibles; DEC VAX and Micro VAX; HP; Sun	$995	C	•	•			
	A-8051PC	8051	IBM PC and compatibles	$395	N/A	•	•	•		
	C-8051PC	8051	IBM PC and compatibles	$995	C					
	Sim-8051PC	8051	IBM PC and compatibles	$995	N/A					•
Boston Systems Office	BSO/Tasking CC8051, PL8051	8051	IBM PC and compatibles; DEC VAX; Sun; HP; Apollo	$1700	C; PL/M	$800	Included with cross assembler		Included with cross assembler	$1800
Micro Computer Control	Micro/SLD	8051; Z8	IBM PC and compatibles	$295	N/A					•
Stag Microsystems	VSDS	(More than 50)	IBM PC and compatibles	$1795	C	•	•			•

Note: N/A = Not applicable.

Demanding Designers Need the Best

OrCAD/SDT III

Schematic Design Tools for the PC

Ease-of-use + Power = Productivity

In today's tough design environment, good engineering tools aren't good enough. You need the best to get the job done.

OrCAD/SDT III offers the power

SDT III comes with the options you'd expect to pay extra for

- **Completeness:** A library of over 6100 parts that you can browse through in a breeze. Utilities to generate Bill-of-Materials, Electrical rules check, create custom library parts.
- **Compatibility:** Over thirty netlist formats; over 50 supported display adapters; over 50 printer drivers; a dozen plotter drivers. We conform to your system better than anyone.
- **Complexity:** 4000+ sheet design capacity for single designs. 200+ levels of hierarchy. Great support for small, simple designs to large, complex hierarchical systems.
- **Control:** SDT III gives you the ability to customize the work environment to make you more productive. This includes user definable macros, text/object sizes, sheet sizes, graphical object editor, even the colors on the screen.

OrCAD/SDT III makes it easy

The lightning fast operation saves time. The intuitive, pop-up menu displays your most likely next action. This means a short learning curve and immediate productivity.

Get our No-risk, Demo Disk

Try before you buy. Get our demonstration disk and see for yourself the solid performance SDT III has to offer.

Once you've given our demo disk a spin, you'll know one of the reasons why OrCAD is the world's leading supplier of PC based CAE tools.

All OrCAD products come complete with one full year of technical telephone support, free product updates and access to our 24 hour BBS.

OrCAD
Systems Corporation

3175 NW Aloclek Drive
Hillsboro, Oregon 97124
(503) 690-9881

If you would like more information about this or any other OrCAD product, contact your local OrCAD representative.

AUSTRIA
Dahms Elektronik
0316/64030-0
Fax: 64030-29

BELGIUM
INEX
(02) 649.99.91
Fax:(02)649.27.92

DENMARK/NORWAY
NordCAD
98 17 32 99
Fax: 98 17 37 41

UK
ARS Microsystems
(0276) 685005
Fax:(0276) 61524

FINLAND
Elektrotel OY
(358 0)754-3122
Fax: 754-2593

FRANCE
ALS Design
(331) 46 04.30.47
Fax: 48 25.93.60

ITALY
BRM Italiana
0117/710010
Fax: 0117/710198

ITALY
MicroData Systems
0187/966123
Fax: 0187/988322

SPAIN
Next-For S.A.
504 02 01
Fax: 504 00 69

SWEDEN
Technology Partners
(468)790 97 75
Fax: (468)16 77 86

SWITZERLAND
Logmatic AG
056/83 38 38
Fax: 056/83 38 40

W. GERMANY
Compware, GmbH
4940/81 80 74
Fax:4940/81 10 37

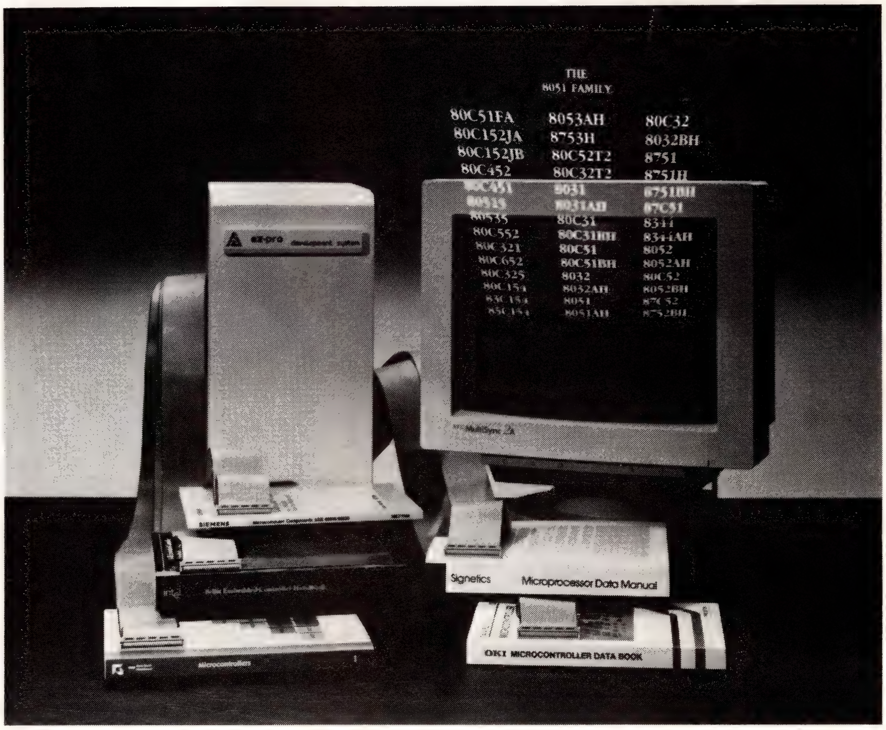
Call or write today for your Demo Disk!

OR8910-INTL

CIRCLE NO. 59

would also sell development tools for that chip. A number of IC manufacturers do offer development systems, but these systems tend to cost more than their third-party counterparts. However, you may receive some added benefits from purchasing your development system directly from the chip manufacturer. For example, Texas Instruments has seven regional technology centers that can provide you with a team of local experts to help you solve the technical problems you may encounter.

For prototype development, you may want to plug a programmable piggyback version of a µC into your circuit. Harris Semiconductor, through its General Electric Solid State Memory Division, offers a µC that provides the functional equivalence of a 6805 and sells for $60. A piggyback chip is a standard µC with an EPROM or static-RAM module embedded on top of the µC for program development.



Third-party high-level-language compilers *are available for a wide range of µCs and can save you programming and debugging time by offering a standardized and easily maintained alternative to programming in assembler. Products such as American Automation's C-language development tools give you additional benefits such as library routines, ROM-able coding, and the ability to mix assembler and C in the same program.*

Makers of in-circuit emulators use a bond-out chip, which is somewhat like a piggyback version of a µC but costs a lot more—$400 to $500. A bond-out chip physically separates the address/data bus from the I/O bus to permit independent access to the internal µC. However, this process is expensive because it involves adding extra pins to the µC and affects the internal architecture of the chip. Accordingly, bond-out chips are typically purchased only by development system vendors.

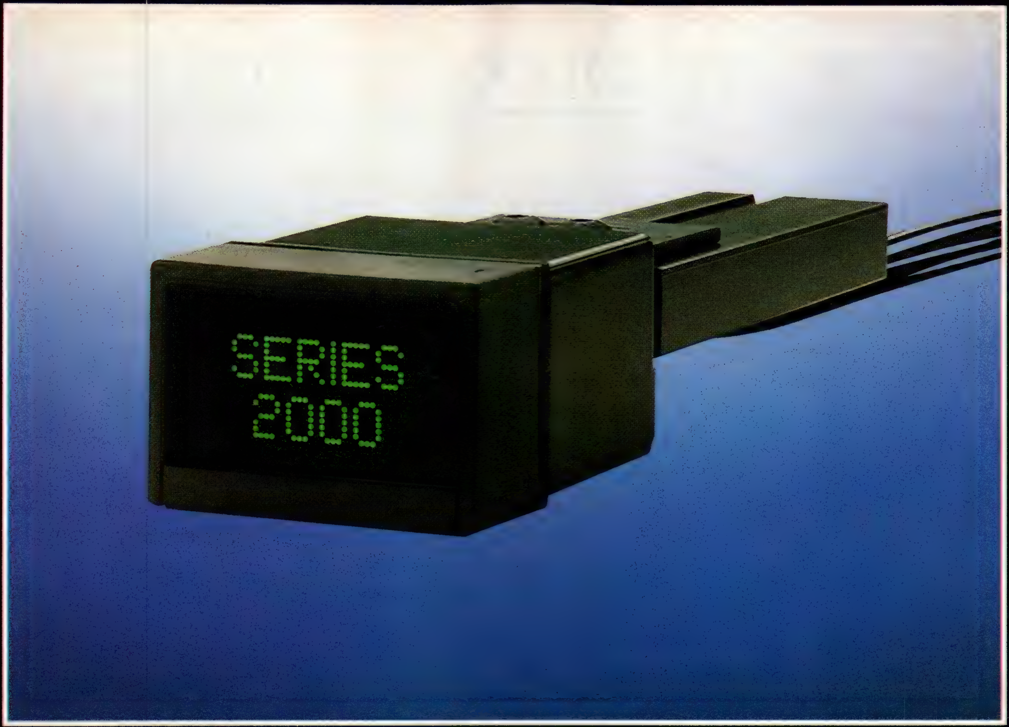
However, an innovation in the design of µCs may change the way you program them, because now ordinary users can go beyond old-hat piggyback versions of a µC and get the capabilities that previously only bond-out-chip users had. Philips-Signetics and MetaLink have announced a scheme for altering the architecture of production-priced µCs so that the I/O ports are multiplexed for external use of the chip's address and data bus. The added circuits, which the companies call "emulation hooks," let you use external memory during the program-development stage of your design. You can then use the chip's internal memory during the prototyping and production stages.

By performing a special command sequence when powering up the µC, you initiate the multiplexing feature. Then, at every clock cycle, the I/O pins alternate between being I/O ports when the chip uses its internal memory and being data/address ports when external memory supplies instructions and data. If you initialize the chip without performing the special command sequence, the µC performs normally.

Philips-Signetics is the sole licensee of this technology, which MetaLink developed, and the company plans to incorporate it into its entire line of 80C51 µCs. With these µCs priced from $2 to $20 in volume, the time and cost of developing and testing embedded systems could decrease significantly. Conceivably, MetaLink and other development-system manufacturers could provide development tools faster and at lower prices because they could tap the emulation hooks in these inexpensive µCs instead of using expensive bond-out chips. However, these development tools would be special development systems that would provide necessary latches and demultiplexing logic to meet the unique I/O requirements of these µCs.

Turn to the programming pros

Applied Microsystems has taken a different approach to shortening the 9-month delay that typically exists between the introduction of a µC and the availability of third-



The program in a switch.

Introducing Vivisun Series 2000, the programmable display pushbutton system that interfaces the operator with the host computer. The user friendly LED dot-matrix displays can display any graphics or alpha-numerics and are available in green, red or amber. They can efficiently guide the operator through any complex sequence, such as a checklist, with no errors and no wasted time.

They also simplify operator training as well as control panel design. Four Vivisun Series 2000 switches can replace 50 or more dedicated switches and the wiring that goes with them. In short, Vivisun Series 2000 gives you more control over everything including your costs.

Contact us today.

AEROSPACE OPTICS INC.
3201 Sandy Lane, Fort Worth, Texas 76112
(817) 451-1141 · Telex 75-8461 · Fax (817) 654-3405

SERIES
VIVISUN 2000™

Programmable display switches. Making the complex simple.

CIRCLE NO. 66

party development tools. The company halved that delay by forming a technical alliance with Motorola to provide development tools for the 8- and 16-bit 68302 Integrated Multiprotocol Processor (IMP) communications controller. The Applied Microsystems' $12,000 ES 1800 development system includes an event-monitoring system and as much as 2M bytes of RAM. You can add a SCSI interface for high-speed data transfers between your host computer and the emulator.

If you work with a number of µCs, you may want to examine Stag Microsystems' Versatile Software Development System (VSDS). This single package provides assembly-level software development for more than 50 µCs and µPs. It also includes a dual-port EPROM emulator that acts as a universal labeling disassembler. The emulator lets you extract object code embedded in EPROM and recreate it as fully labeled source-code modules. The text editor lets you simultaneously display and edit two files in separate windows. VSDS also has an intelligent batch-file manager called Make, which lets you reassemble all the modified modules of your code, link them into a single object-code file, and then load the file—all with a single keystroke. The company of-

For more information . . .

For more information on the 8-bit microcontroller development products discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

Allen Systems
2346 Brandon Rd
Columbus, OH 43221
(614) 488-7122
Circle No. 800

American Automation
2651 Dow Ave
Tustin, CA 92680
(714) 731-1661
FAX 714-731-1661
Circle No. 801

Applied Microsystems
5020 148th Ave NE
Redmond, WA 98073
(800) 426-3925;
in WA, (208) 882-2000
FAX 208-883-3049
Circle No. 802

Archimedes Software
2159 Union St
San Francisco, CA 94123
(415) 567-4010
FAX 415-567-1318
Circle No. 803

Ashling Microsystems Ltd
Plassey Technological Park
Limerick, Ireland
353-61-334466
FAX 353-61-334477
TLX 70357 ASHL EI
Circle No. 804

Boston Systems Office
411 Waverley Oaks Rd
Waltham, MA 02154
(617) 894-7800
FAX 617-642-5762
Circle No. 805

Fujitsu Microelectronics Inc
Integrated Circuits Div
3545 N First St
San Jose, CA 95134
(408) 922-9000
FAX 408-432-9044
Circle No. 806

Harris Semiconductor
Box 883, MS 62A-021
Melborne, FL 32902
(407) 724-7302
FAX 407-729-4960
Circle No. 807

Huntsville Microsystems Inc
4040 S Memorial Pkwy
Huntsville, AL 35802
(205) 881-6005
FAX 205-882-6701
Circle No. 808

Macrochip Research Inc
1301 N Denton Dr, Suite 204
Carrollton, TX 75006
(214) 242-0450
FAX 214-245-1005
Circle No. 809

Metalink Corp
325 E Elliot Rd, Suite 23
Chandler, AZ 85225
(800) 638-2423;
in AZ, (602) 926-0797
FAX 602-926-1198
Circle No. 810

Micro Computer Control Corp
Box 275
Hopewell, NJ 08525
(609) 466-1751
FAX 609-466-4116
Circle No. 811

Mitsubishi Electronics America Ltd
Semiconductor Div
1050 E Arques Ave
Sunnyvale, CA 94086
(408) 730-5900
Circle No. 812

National Semiconductor Corp
2900 Semiconductor Dr
Santa Clara, CA 95052
(408) 721-5000
TWX 910-339-9240
Circle No. 813

OKI Semiconductor Inc
650 N Mary Ave
Sunnyvale, CA 94086
(408) 720-1900
FAX 408-720-1918
Circle No. 814

Philips Components
Signetics Co
811 E Arques Ave
Sunnyvale, CA 94088
(408) 991-2000
Circle No. 815

Quickturn Systems Inc
1023 N Shoreline Blvd
Mountain View, CA 94043
(415) 967-3300
FAX 415-967-3199
Circle No. 816

SGS-Thomson Microelectronics Inc
1000 E Bell Rd
Phoenix, AZ 85022
(602) 867-6100
FAX 602-867-6102
Circle No. 817

Sophia Systems
3337 Kifer Rd
Santa Clara, CA 95051
(408) 733-1571
FAX 408-749-8172
Circle No. 818

Softaid Inc
8930 Rte 108
Columbia, MD 21045
(800) 433-8812;
in MD, (310) 964-8455
FAX 301-596-1852
Circle No. 819

Stag Microsystems Inc
1600 Wyatt Dr
Santa Clara, CA 95050
(408) 988-1118
TWX 910-339-9607
Circle No. 820

Texas Instruments
Semiconductor Group
Box 1443, MS 719
Houston, TX 77251
(800) 232-3200, ext 3525;
in TX, (713) 274-2370
Circle No. 821

Zax Corp
2572 White Rd
Irvine, CA 92714
(714) 474-1170
FAX 714 474-0159
Circle No. 822

VOTE . . .

Please also use the Information Retrieval Service card to rate this article (circle one):

High Interest 506 Medium Interest 507
Low Interest 508

For Superior Dielectric Strength and Flame Retardance, Insulate with VALOX® Film.

With UL94 V-0* or VTM-0* flame resistance and dielectric strength of 5000 volts/mil @ .001″, VALOX FR-1 film out-performs other polyester films. It also die cuts better than most insulative materials, is easily laminated to other surfaces with a variety of adhesives—and provides a cost-effective alternative to Nomex†.

TEKRA can meet all your insulative film needs with custom-converted sheets and rolls plus in-stock availability of high-performance VALOX, LEXAN® and ULTEM® films from GE Plastics.

TEKRA CORPORATION, 16700 West Lincoln Ave., New Berlin, WI 53151, (800) HI-TEKRA (448-3572)

TEKRA
Innovation in film technology

® Registered Trademarks of General Electric Company.
† Registered Trademark of E.I. Dupont deNemours and Co., Inc.
* This rating is not intended to reflect hazards presented by this or any other material under actual fire conditions.

TEK-78

fers a free demonstration disk that presents the features of VSDS.

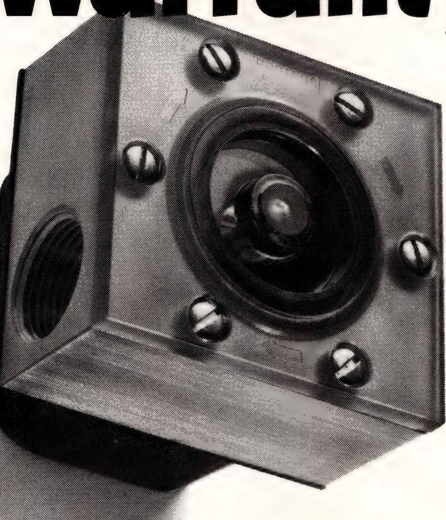
Zax Corp has a development system for 6801, 6803, 6301, and 6303 μCs that includes an Ethernet interface for networking with an assortment of workstations and computers. You could instead specify an IBM PC/AT-bus interface for simple integration with your IBM PC/AT-compatible computer. Zax's ERX series emulators provide symbolic debugging, real-time performance analysis, real-time trace analysis, and as many as 256,000 breakpoints.

If you decide to mix development hardware and software from different manufacturers, be sure to select a compiler, a source-level debugger, and an emulator that will work in concert and let you perform your programming task most effectively. For example, Softaid recommends using Archimedes's C with its 647180X IceAlyzer development system because the Archimedes compiler generates extensive files of debugging data that the Softaid source-level debugger can access and utilize. Note that not all compilers generate enough cross-reference information for debuggers—a distinction you should investigate before purchasing a compiler.

In fact, Archimedes Software has a line of C cross compilers for most μCs and provides output formats for a wide assortment of PROM programmers and μC emulators. You can request a free demonstration disk that presents the C tools offered by the company. In addition, Archimedes has a simulator/debugger called SimCASE and a set of I/O simulation tools called SimI/O. **EDN**

Article Interest Quotient
(Circle One)
High 506 Medium 507 Low 508

Proteus Flow Switch Five Year Warranty.



• 0.08 - 30 GPM
• 100° C
• Adjustable Trip Point

A decade of leadership in active flow switches permits Proteus to announce a five year warranty.
Choose Proteus when reliability counts.

Proteus Industries Inc.

340 Pioneer Way, Mountain View, CA 94041
Phone: (415) 964-4163 • FAX (415) 965-9355
CIRCLE NO. 6

EDN INFO CARDS
DONNA PONO (617) 558-4282

THE 2¢ SOLUTION

EDN Magazine Edition News Edition

A Partnership in Power and Prestige Worldwide

GOODBYE WORKSTATION

HELLO PADS-PCB

It's time to say goodbye

to expensive engineering workstation based CAD systems. Why should management tie up $100,000.00 or more in a workstation when the same (and often better) performance is obtained with PADS-PCB, a PC based CAD system?

PADS-PCB is a high performance printed circuit board design software that offers a degree of functionality a designer could expect only from an expensive engineering workstation, including Logic Simulation, Circuit Analysis, and Thermal Analysis.

Powerful auto/interactive features are a part of what makes PADS-PCB the best selling CAD system on the market today!

- 1 mil database-32″x32″ board size-30 layers
- Large circuit capabilites: In excess of 400 equivalent 14 pin IC's
- Automatic and interactive component placement aids
- Automatic and interactive track routing
- Automatic design rule checking
- Superior Surface Mounted Device capability
- Fine line design
- Superb analog design capability
- Inputs from Futurenet, Orcad, Schema, PADS-LOGIC and others
- 100% routing with PADS-SuperRouter, the accepted standard for rip-up and reroute autorouting
- *New!* PADS-Push N' Shove Auto-Interactive Push N' Shove Router. Great for analog and critical circuitry.

CAD Software asks you to try its Evaluation Package, at no charge, so you can judge for yourself how PADS-PCB can be the solution to your design problems. Ask about our Leasing Program. Call our Sales Hotline today at **(800) 255-7814;** in Massachusetts, **(508) 486-8929.**

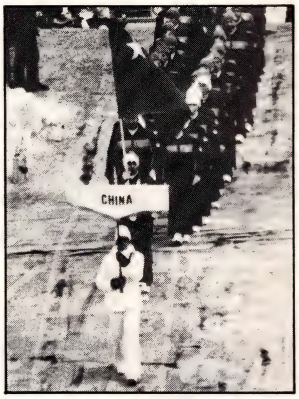
119 Russell Street
Suite #6
Littleton, MA 01460

CAD
Software, Inc.

In 1979, Evelyn Ashford breaks 11 sec. in the 100-m dash for the 1st time…

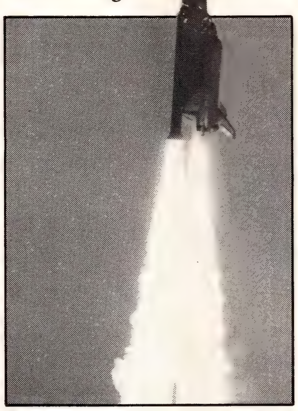
and EDN takes 1st place in readership.

In 1980, the first-ever Chinese Olympic team attends the Winter Games…



and EDN wins 1st place in readership.

In 1981, the Columbia makes the first space shuttle flight…

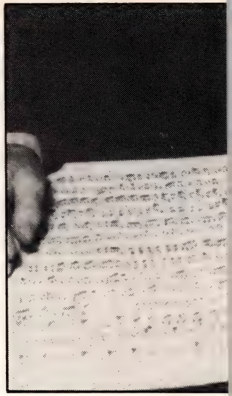


and EDN soars – finishing 1st in readership.

In 1982, Lady Diana, Princess of Wales, has her first child…

and EDN reigns as 1st in readership.

In 1983, the first symp
written by Mozart (at
nine) is discovered…



and EDN is discovere
be 1st in readership.

FIR

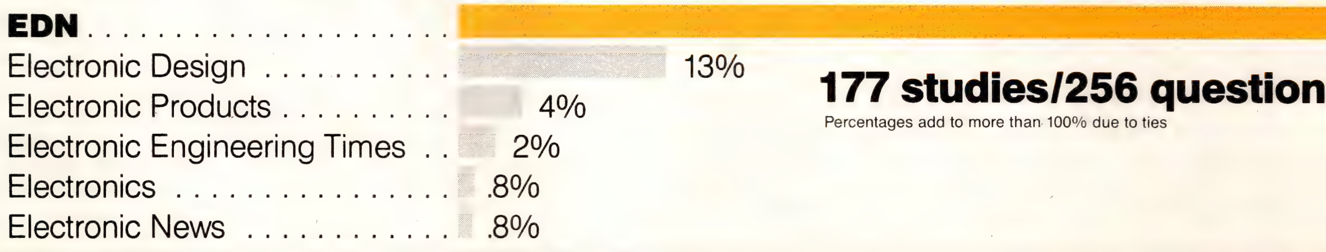
First. It's The Only Place To Be. Since 1978, Onl To Be Second To None…EDN. And EDN

Winning one study doesn't make a first. But winning 84% of 177 independent readership studies since 1978 puts EDN first in readership. That's more wins than the rest of the electronics publications combined.

Announcing 7 new EDN independe

	EDN	Electronic
Zenith Electronics	#1	5
Sprague Semiconductor	#1	5
SGS Thomson Semiconductor	#1	5
3M	#1	5
Apex Technology	#1	5
Sipex Corporation	#1	4
Kyocera Northwest, Inc.	#1	NOT INCL.

CUMULATIVE WINS –
% of Readership/Reader Preference Wins* 1978–1989 (to date)



177 studies/256 question

Percentages add to more than 100% due to ties

---

*Independent studies are conducted across customer/prospects lists or TIDS lists, not across a magazine's or newspaper's own list, which results in obvious bias. **Results based on the que

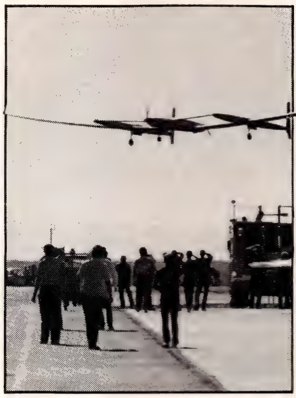
84, Kathryn Sullivan
e first woman to walk
ace...

EDN walks away
a 1st in readership.

In 1985, Reagan and Gorbachev hold their first summit...

and EDN holds its 1st place in readership.

In 1986, the first non-stop flight around the world without refueling is successful...



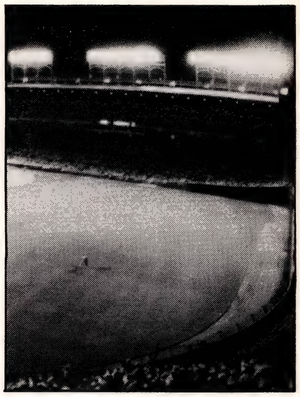
and EDN flies highest as 1st in readership.

In 1987, the Rotary Club admits women for the first time...

ROTARY INTERNATIONAL

and EDN is elected 1st in readership.

In 1988, Wrigley Field in Chicago lights up for the first time...



and EDN shines as 1st in readership.

STS

One Electronics Publication Knows What It's Like
Leadership In Readership Reign Continues.

adership/reader preference study* wins:**

Electronic Design	Electronic Products	EE Times	Electronic News
2	4	3	NOT INCL.
2	4	3	NOT INCL.
4	3	2	NOT INCL.
2	4	3	6
2	3	4	NOT INCL.
2	NOT INCL.	3	NOT INCL.
3	2	4	5

If you would like to see the complete record of EDN's readership wins, contact your local sales representative. EDN will send you a six-foot long brochure that proves first is the only place to be.

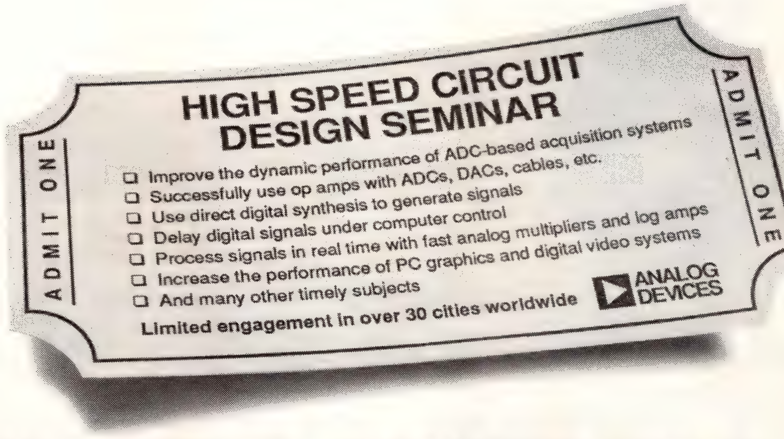
And only a publication in first place dares to offer $1000 to anyone who can disprove its claim to readership. No other electronic engineering magazine or newspaper in the world has won more independent readership/reader preference studies than EDN.

EDN Magazine Edition
News Edition

A Partnership in Power & Prestige Worldwide

---

ch of these publications do you read regularly (3 out of 4 issues)?" in each study.



ADMIT ONE

HIGH SPEED CIRCUIT
DESIGN SEMINAR

- ☐ Improve the dynamic performance of ADC-based acquisition systems
- ☐ Successfully use op amps with ADCs, DACs, cables, etc.
- ☐ Use direct digital synthesis to generate signals
- ☐ Delay digital signals under computer control
- ☐ Process signals in real time with fast analog multipliers and log amps
- ☐ Increase the performance of PC graphics and digital video systems
- ☐ And many other timely subjects

Limited engagement in over 30 cities worldwide

ANALOG DEVICES

ADMIT ONE

IF YOU GET A SPEEDING TICKET

The book is our High Speed Design manual, with over 400 pages of comprehensive technical information.

But that's not all you'll get when you attend our full-day High Speed Design Seminar.

If you're working with signals in the megahertz to gigahertz range, you'll also come away knowing how to get your design to work quickly. How to save money by choosing the right components. Ways to cut down on design time by using new techniques. And how to accurately test the performance of your parts and systems.

Specific topics include everything from high speed a/d conversion and wide bandwidth amplification, to high speed non-linear signal processing, digital video and graphics, and time domain functions.

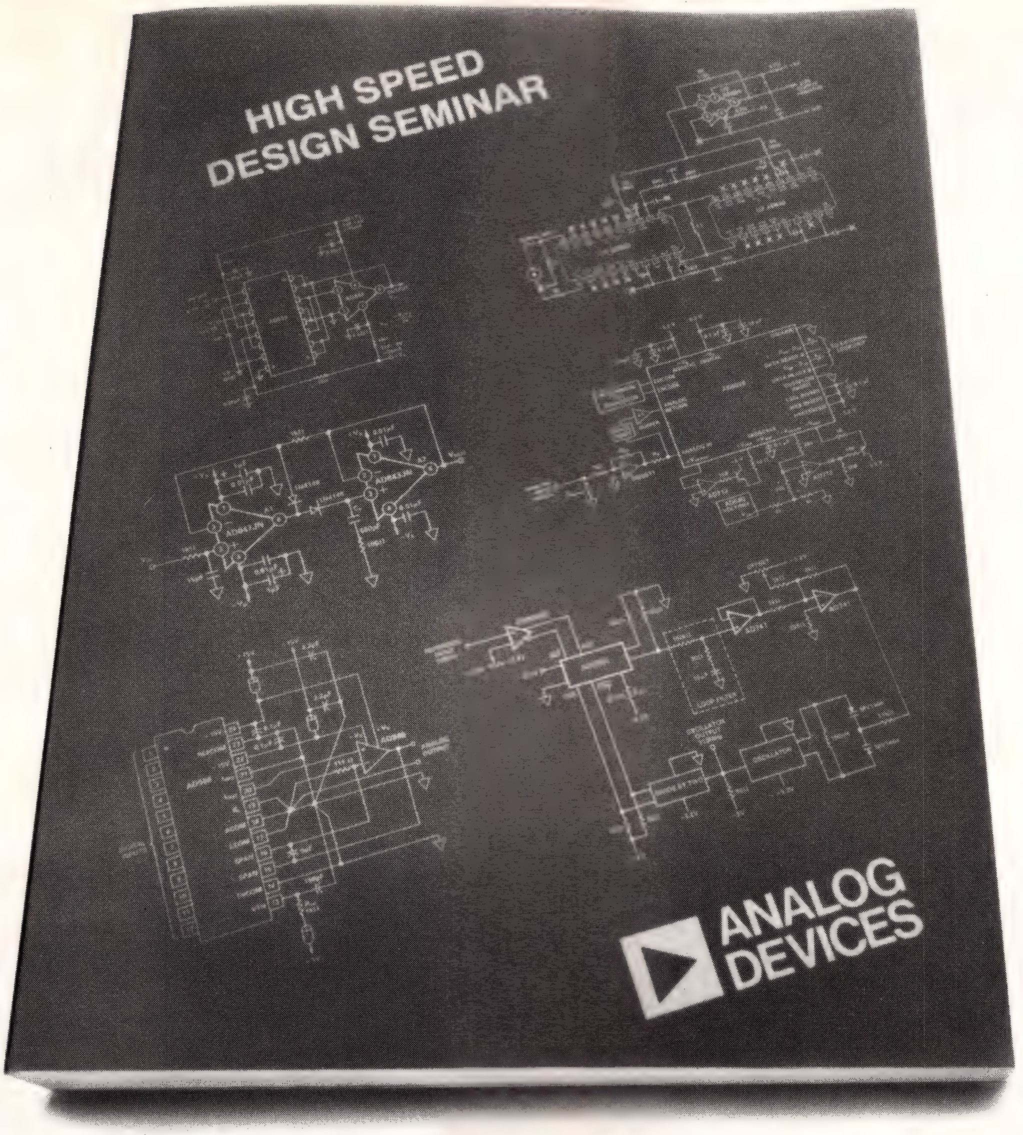
And since the seminar is conducted by Analog Devices, you'll be learning from the company that, with over 25 years of experience, has become the leader in high speed design. A company which continues to advance that position by offering the fastest products and the broadest high speed product portfolio.

If you're into high speed design, you should be in this seminar. You'll not only receive the seminar manual, but also a variety of useful literature, a product sample kit, and lunch.

This is one speeding ticket you'll be glad to get, and it'll only cost you $20. To get yours, just fill out and return the attached coupon with your check. Or call 1-800-ANALOGD.

Tickets are limited, though, so you'd better step on it.

Austria: (222) 885504-0; Belgium: (3) 237 1672; Denmark: (42) 845800; France: (1) 4666-25-25; Holland: (1620) 81500; Israel: (52) 911415; Italy: (2) 6140977, (2) 6143484, (2) 6143459;
Japan: (3) 263-6826; Korea: (2) 5543301; Sweden: (8) 282740; Switzerland: (22) 731 57 60; United Kingdom: (932) 232222; West Germany: (89) 570050.



WE'LL THROW THE BOOK AT YOU.

☐ Yes, I want to attend your High Speed Design Seminar.
Reserve my space in a hurry.

Name ____________________
Title ____________________
Company ____________________
Address ____________________
City __________ State __________ Zip __________

I am currently involved in High Speed Design. Yes ____ No ____
Application ____________________
I'd like to attend in the following city: ____________________
Date: ____________________

Please include a check for $20 payable to: Analog Devices
Return to: Analog Devices, High Speed Design Seminar,
181 Ballardvale St., Wilmington, MA 01887.
For more information, call 1-800-ANALOGD (1-800-262-5643).

March Melbourne, FL – 3/19 • Atlanta, GA – 3/20 • Huntsville, AL – 3/21 • Baltimore, MD – 3/22 • Tysons Corner, VA – 3/23 • Santa Clara, CA – 3/29 • Pleasanton, CA – 3/30

April San Diego, CA – 4/2 • Irvine, CA – 4/3 • Los Angeles, CA – 4/4 • Woodland Hills, CA – 4/5 • Phoenix, AZ – 4/9 • Denver, CO – 4/10 • Richardson, TX – 4/11 • Arlington Heights, IL – 4/12 • Andover, MA – 4/16 • Ft. Washington, PA – 4/17 • Smithtown, NY – 4/18 • Saddlebrook, NJ – 4/19 • Bloomington, MN – 4/23 • Rochester, NY – 4/24 • Toronto, CAN – 4/25 • Montreal, CAN – 4/26

May Newton, MA – 5/1 • Bellevue, WA – 5/2 • Beaverton, OR – 5/3 •

Multiple sites in Europe and the Far East.

ANALOG
DEVICES

THE HIGH SPEED DESIGN SEMINAR FROM ANALOG DEVICES.

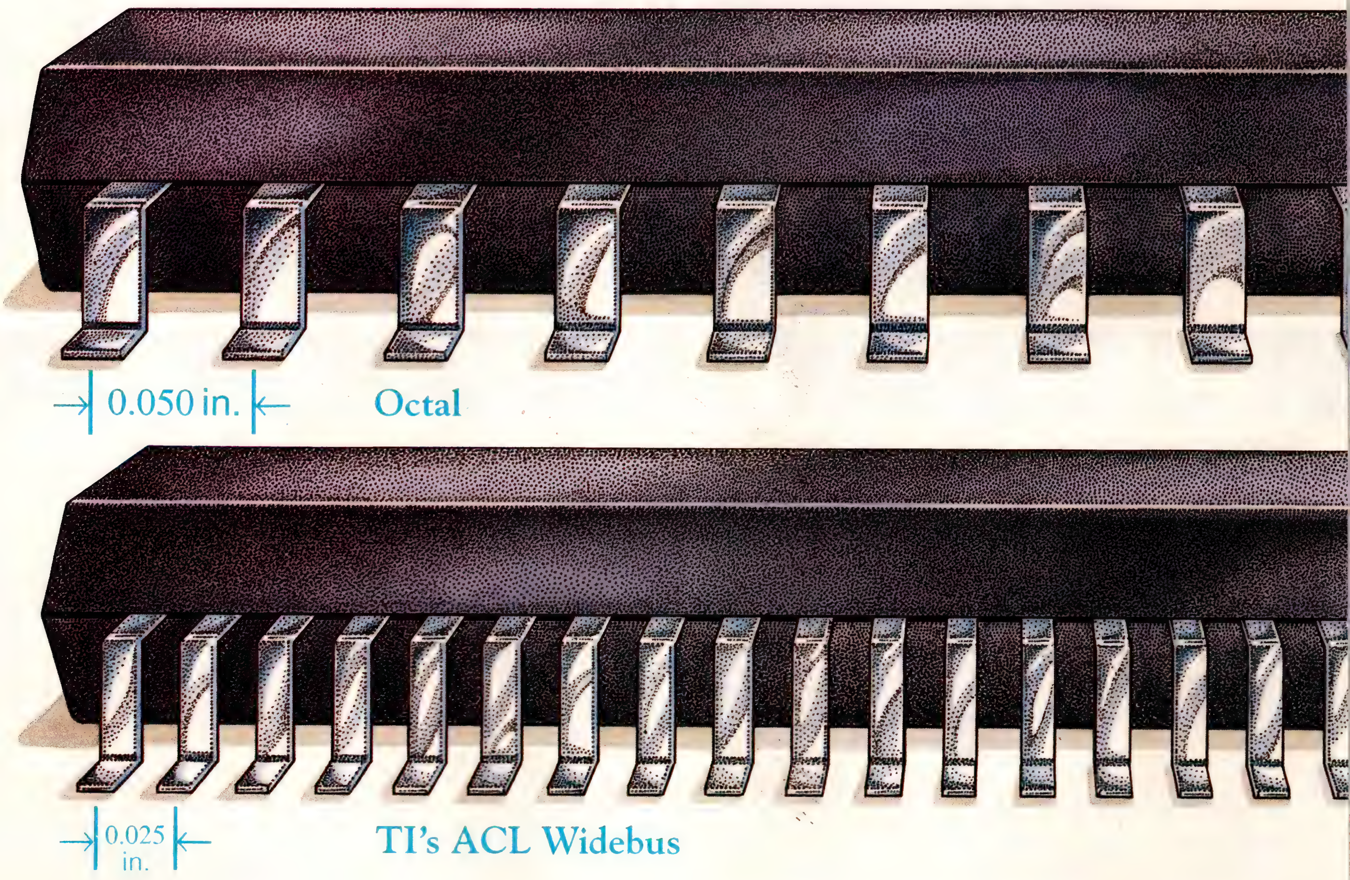
CIRCLE NO. 65

IN THE ERA OF MegaChip™ TECHNOLOGIES

THE ADVANTAGES

Introducing TI's ACL Widebus Series for wide-word systems. Having twice as many I/Os in the same size package boosts performance, saves space, cuts costs.

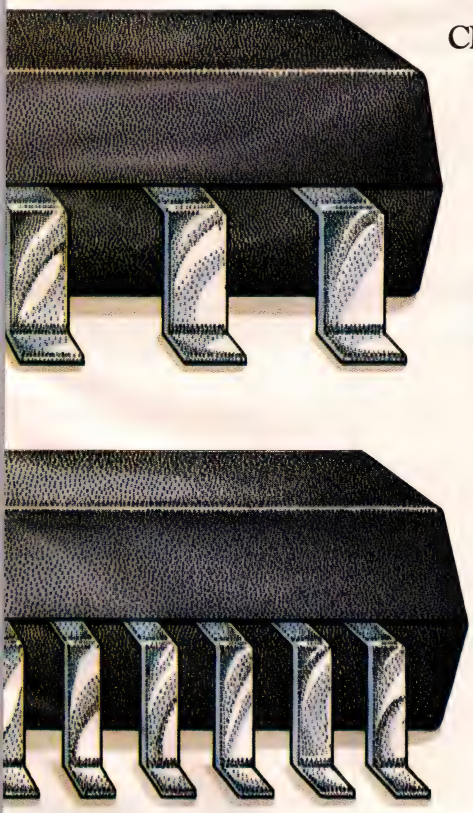
The trend is growing: Wider use of wider architectures and surface-mount technologies by designers of advanced systems. Performance and reliability requirements are demanding. As a resu TI is introducing its new ACL Widebu Series of 16-, 18-, and 20-bit bus-interfa functions. They are excellent choices fc laptop and notebook-size PCs, office-au mation products, computer peripherals, minicomputers and single-board computers, telecommunications, and milita applications such as radar and imaging.


0.050 in.
Octal
0.025 in.
TI's ACL Widebus

OF SEEING DOUBLE

hrinking 24 pins down to 48

28 down to 56. No, it's not some form
"new math." It's our newly developed
rink small-outline package (SSOP) that
ubles the number of I/Os there are on a
ndard small-outline package *in the same*
ount of board space. Looking at it
other way, the SSOP lets you maintain
ur I/O count *in half the space*. TI is the
st to make 48- and 56-pin devices avail-
le in SSOPs, which feature 25-mil
nter-to-center pin spacing.
The SSOP package, combined with TI's
ique "flow-through" architecture that



simplifies board design, enables you to save enough space to either reduce system size or add performance enhancements.

Designing made easier

You'll have maximum flexibility designing with our new Widebus Series. You can use each Widebus function at its full 16-, 18-, or 20-bit width or as dual, independently controlled, eight-, nine-, or 10-bit functions.

In addition, each Widebus device comes in CMOS-compatible (AC) and TTL-compatible (ACT) versions. Devices processed to MIL-STD-883, Class B, will be available.

CMOS power savings, speed/performance on par with bipolar

Our Widebus Series is fabricated in one-micron EPIC™ CMOS technology that minimizes propagation delays and reduces power dissipation to essentially zero at standby.

Typical data-path delay for a 16-bit, noninverting, bidirectional Widebus transceiver is 6.9 ns. That's comparable to advanced bipolar 54/74F devices.

There's more. While simultaneous switching is common in high-performance systems, laboratory results show that the noise generated by our ACL Widebus functions is less than 1 V. Distributed V_{CC} and ground pins plus Output Edge Control (OEC™) are additional techniques we use for reducing noise and improving system reliability.

As far as output-drive capabilities are concerned, we're designing the Widebus Series to provide 24-mA sink and source currents and the capability to drive 50-ohm transmission lines.

The big family is on its way

Widebus functions are available today. The family will consist of approximately 50 Widebus functions including 16-, 18-, and 20-bit bus drivers, bus transceivers, D-type latches, D-type flip-flops, storage transceivers, and registered bus transceivers.

Texas Instruments

Advanced Logic Products

ACL Widebus Series doubles the I/Os to wide-word architectures

For more information and a free sample of our Widebus family: **In Europe**, call Deutschland (08161) 800; Italia (039) 63221; France (1) 30 70 10 03; U.K. (0234) 223000. **In the Far East**, call Japan 81-3-769-8700; Singapore 65-251-9818; Hong Kong 852-735-1223; Australia 61-2-887-1122.

™ Trademark of Texas Instruments Incorporated
© 1990 TI

08-9424 B

TEXAS INSTRUMENTS

Samtec *guarantees* shipment of over a thousand commonly specified connectors.

IN STOCK

Shipped within 1 day... Samples are shipped by air within one day of request.

Shipped within 2 days... Up to 500 of any connector in our current In-Stock Catalog shipped within 2 days of your order, or you don't pay the freight.*

Shipped within 3 days... If your order for up to 500 connectors from our current In-Stock Catalog isn't shipped within three days, you get them free.* Your account will be credited for the full amount of the connectors, plus freight!

Samtec "Sudden Service" is *guaranteed* service. Don't delay. Call Samtec today for our new In-Stock Catalog.

812-944-6733

* Subject to approved credit. Guarantees apply to full work days from receipt of order; weekends and holidays are excluded. Products shown in the in-Stock catalog may vary by market and are subject to change.

samtec IS SUDDEN SERVICE

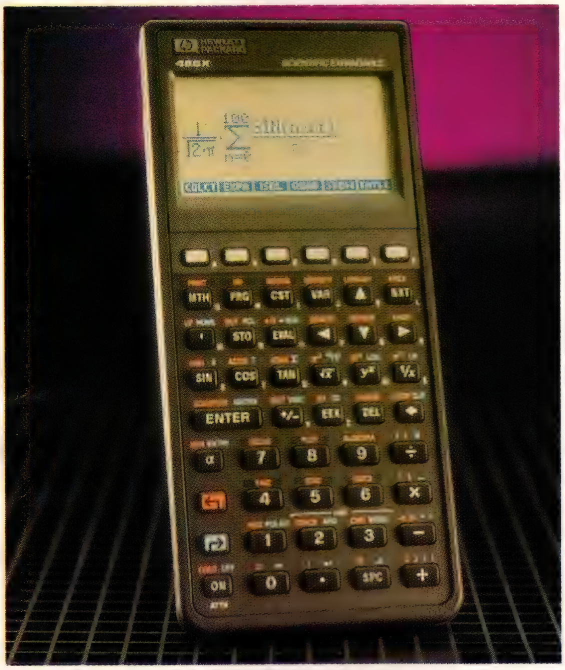
New Albany, Indiana USA • Sacramento, California USA • Cumbernauld, Scotland UK • Singapore
SAMTEC, INC. • P.O. Box 1147 • 810 Progress Boulevard • New Albany, IN 47150 USA • Tel 812-944-6733 • Fax 812-948-5047 • Twx 810-540-4095 • Tlx 333-918

EDN EDITORS' CHOICE
INNOVATION™

Handheld scientific calculator is actually a PC math package in disguise

Hewlett-Packard's HP 48SX scientific calculator has many features and functions not found on any other scientific calculator—and the highest base price at $350. But you can couple the calculator to an IBM PC or Macintosh personal computer and, using a $99.95 serial adapter, transform the calculator into a math package.

Mechanically, this replacement for the HP 41 differs significantly from the company's last top-of-the-line calculator, which comes in a 2-part plastic case that opens up like a book. The 48SX has a more conventional 1-piece case. It can accept two RAM or ROM expansion cards, and it has bidirectional infrared and RS-232C ports.



***Providing more functions than any other scientific calculator,** the HP 48SX can exchange data and programs between the calculator and a PC. It can also communicate back to back with another 48SX via its infrared port.*

Not only can you exchange data and programs between the calculator and a personal computer, but you can also put two calculators back to back and have them communicate through their infrared ports. This invisible, silent, calculator-to-calculator communication might seem to be a new way for students to cheat during tests. However, the high baud rate limits the range to a matter of inches.

Aside from a handful of common functions available on dedicated keys, you access most of the calculator's more than 2100 functions with menus and soft keys. Describing all these functions takes up two manuals—far more room than we have here. But a few functions stand out and are worth mentioning.

The earliest programmable calculators processed strings of incomprehensible key presses. Later programmables used series of Fortran- or Basic-like operators. The 48SX tops the computer-like programmables by allowing you to draw, and later edit, your equations in standard mathematical form on its 8-line × 26-character graphics LCD. Once you're satisfied with the setup of your equation, a press of the Enter button translates the equation into the calculator's format and pushes the transformed equation onto the stack.

The calculator can simplify, solve, differentiate, or integrate many functions automatically. You can graph these functions several different ways and pick values, such as x or y intercepts, or local maxima or minima, off the graph and push them onto the stack. The 48SX also provides a spreadsheet for entering matrix values.

If you enter an equation with several variables, the calculator will set up soft keys for the variables. You can then enter values for all but one variable, and the calculator will automatically solve the equation for the remaining variable.

You can attach units to any number or variable. From then on the calculator will keep track of the units, doing conversions where possible and flagging illegal operations. For example, if you divide a quantity whose units are ft/sec by a quantity whose units are in seconds, the answer will automatically acquire ft/sec^2 as its unit. And, oh yes, you can enter operations and programs either in standard algebraic or in the company's famous reverse-Polish notation.

The 7.1×3.2×1.15-in., 9-oz HP 48SX uses 3 AAA cells. Math-pack ROM cards to use with the 48SX cost $99.95. A 32k-byte, battery-backed RAM card is $79.95, and its 128k-byte version sells for $250. An infrared-coupled printer sells for $135.—***Charles H Small***

Hewlett-Packard, Inquiries Manager, 1000 NE Circle Blvd, Corvallis, OR 97330. Phone local office.

Circle No. 730

High-resolution workstations combine features of MS-DOS and Unix machines

Is it a bird, is it a plain PC, or is it a workstation?

Well, the Series 1000, 3000, and 4000 run Unix System V Release 3.2. The higher-end Series 3000 and 4000 feature high-resolution graphics of 20M pixels/sec. And, all three machines contain integrated networking capabilites via Network File System (NFS) and TCP/IP (Transmission Control Protocol/Internet Protocol) over Ethernet. According to the vendor, these features qualify the machines as workstations.

On the other hand, the Series 1000, 3000, and 4000 share the ability to run native-mode MS-DOS and are built around the 80x86 family; the Series 1000 starts with a 16-MHz 80386SX, the 3000 uses a 25-MHz 80386, and the 4000 contains a 25-MHz 80486. In addition, the 1000, 3000, and 4000 accept four, eight, and eight ISA (Industry Standard Architecture) cards, respectively. Power supplies on the boxes provide 145, 220, and 303W.

The Series 1000 Model 16D is a 3 VAX MIPS machine with an 80387SX coprocessor. The machine contains 4M bytes of RAM that you can expand to 8M bytes. For mass storage, you can choose from a 5¼-in. floppy-disk drive with 1.2M-byte capacity, hard drives that store 70M to 340M bytes, and a 150M-byte tape drive. With 4M bytes of RAM, one 80M-byte hard drive, a floppy-disk drive, and Unix and X-Window software, the 1016D costs $6295.

A midrange system, the 3000 Model 25D is a 6 VAX MIPS machine. This model features an 80387 coprocessor, 64k-bytes of cache memory, and between 8M and 40M bytes of RAM. Mass storage options include a 5¼-in. 1.2M-byte floppy-disk drive; 170M-, 380M-, and 760M-byte SCSI hard disks; and a 150M-byte SCSI tape drive. Video options range from 800 × 600-pixel extended VGA with 16 colors to 1280 × 1024 pixels with 256 colors from a 4k palette. Configured with 8M bytes of RAM, one 170M-byte SCSI disk drive, two floppy-disk drives, extended VGA controller and monitor, and Unix and X-Window software, the 3025D costs $11,495.

Many appealing features of personal computers and workstations, *including high-resolution graphics, come together in the Series 1000, 3000, and 4000 (shown) workstations.*

Finally, the high-end workstation is the 12 VAX MIPS Series 4000 Model 25T. The 80486 that powers the system contains an 8k-byte cache and a floating-point processor. To the base configuration of 8M bytes of RAM, you can add as much as 24M bytes more. The Series 3000 and 4000 share data storage and video options. Configured like the 3025D, the 4025T costs $14,595.

The vendor is targeting OEM customers for these machines by offering a support program to assist product development. This program includes 24-hour, 7-day telephone technical support, on-site consulting, and training.

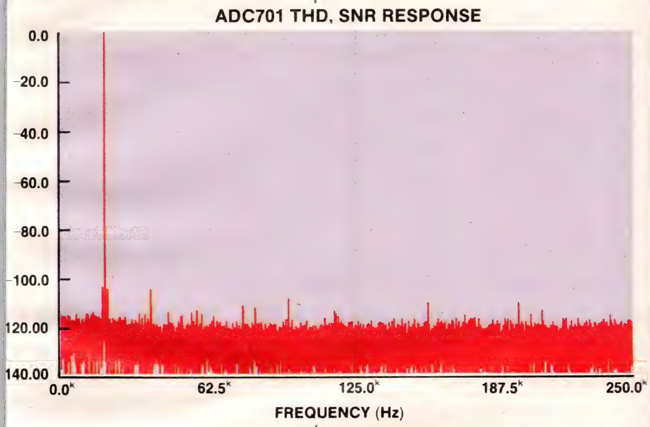
So, the Series 1000, 3000, and 4000 computers are clearly not birds. And while they also are clearly not plain PCs, these machines seem to blend many of the features of PCs and workstations. As a result, the division between PCs and workstations is growing smaller and smaller.

—Michael C Markowitz

Intel Corp, 5200 NE Elam Young Pkwy, Hillsboro, OR 97124. Phone (503) 681-8080. **Circle No. 733**

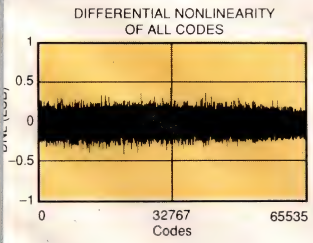
New 16-Bit, 500kHz Sampling A/D System

Advanced Signal Processing Solutions



Our new high performance analog-o-digital conversion ystem is specifically designed and tested to excel in demanding ATE, FFT spectrum analysis, imaging, professional audio, and other advanced signal processing applications.

he new system comprises a matched pair of hybrid components: the SHC702 sample/hold amplifier and the ADC701 16-bit A/D converter. The ADC uses hree-step subranging or fast, accurate conversions.



Unmatched Spurious-Free Dynamic Range

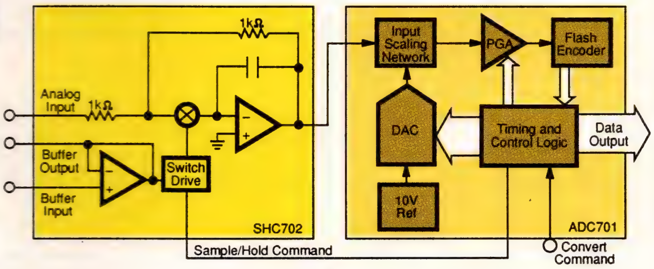
Together, SHC702 and ADC701 form a very compact, fast, low-distortion system with exceptional spurious-free dynamic range and low power consumption. Features include:

- 16-bit resolution
- DC to 500kHz conversion rate
- 107dB spurious-free dynamic range (20kHz)
- 0.00068% THD (20kHz), 0.0078% THD (199kHz)
- -81.4dBc IMD (195/200kHz)
- 93dB SNR (5kHz)
- ±0.002% FSR dynamic nonlinearity
- no missing codes guaranteed

Big Space Savings!

These new components employ our advanced monolithic technology to give you better performance and reliability than modular devices plus a lot more board space to work with. SHC702's 24-pin metal DIP measures only 1.4" x 0.8", and ADC701's 40-pin ceramic/metal DIP is only 2.1" x 1.1".

- 0/+5V, 0/+10V, -10/0V, ±5V, and ±10V input ranges
- CMOS/TTL compatible
- 2.8W combined power dissipation
- internal +10V reference
- ±10ppm/°C gain stability
- demonstration board and complete layout information available



Burr-Brown Corp., P.O.
Box 11400, Tucson, AZ
85734.

BURR-BROWN®

Continuous-time filter IC handles 4-MHz signals and offers programmability

If you need programmable filter ICs to handle high frequencies, you should consider the IMP4250, which allows you to specify frequency-response poles from 100 kHz to 4 MHz and zeros to 8 MHz. This filter IC, originally intended for magnetic-storage applications, has a great deal of flexibility. It consists of an input buffer, four independent filter sections, and an output amplifier.

Two of the filter sections are first order, and two are second order. You can independently program each coefficient of each section's transfer characteristic, as well as specify their corner frequencies. You can also program the device to bypass each section.

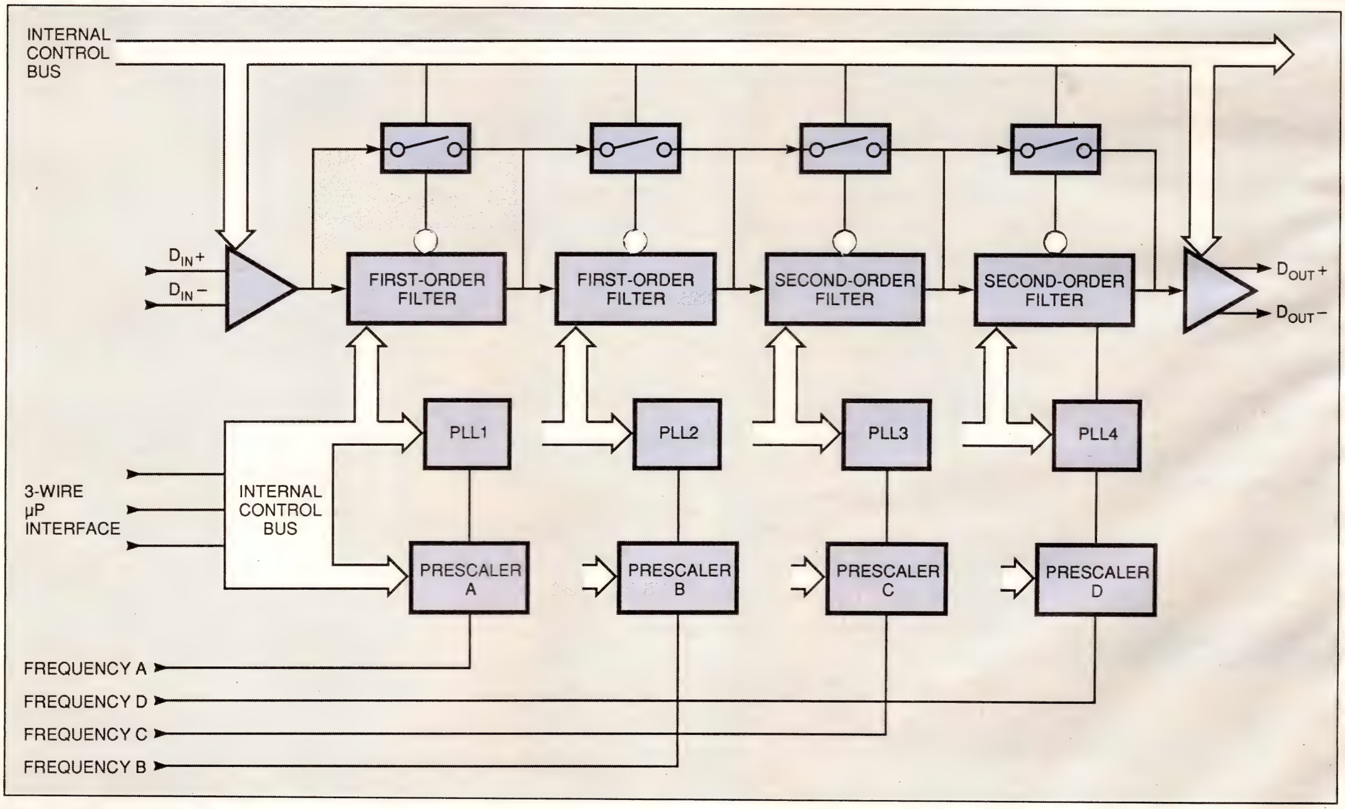
The filter doesn't use switched-capacitor or any other sampling techniques; it's a continuous-time active filter, so there's no signal aliasing. Instead, a voltage-controlled resistor in an op-amp filter sets the device's frequency response.

A phase-locked loop provides the frequency-control voltage for each section. The PLL maintains the filter's frequency response to ±3%. You select the frequency you need by providing a reference clock and programming a frequency divider in the PLL. You may use the same reference clock for each section or provide separate clocks. The device has a built-in oscillator, allowing you to use a crystal to create the reference clock.

You program the device through a 3-wire serial interface: data in, data out, and shift clock. You can write to or read from the 18 registers at any time, allowing you to dynamically adjust the device's frequency response. Writing to a register takes 25 µsec.

The device is ac-coupled and operates on 0 to 5V differential signals. It operates from a single 5V supply, drawing 100 mA. The 24-pin DIP sells for $18, and the 28-lead plastic leaded chip carrier costs $18.50 (1000). Samples will be available in April.—***Richard A Quinnell***

International Microelectronic Products, 70 E Daggett Dr, San Jose, CA 95134. Phone (408) 432-9100. **Circle No. 732**

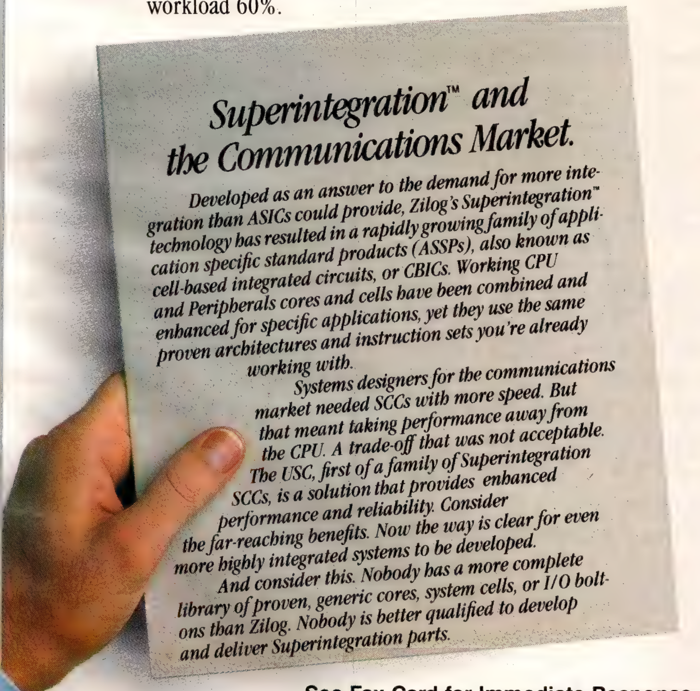


Handling frequencies to 4 MHz, *this filter IC offers four cascaded sections, each independently programmable. Its frequency response is stable to ±3%.*

ZILOG

The next standard.
A new generation of high performance SCCs.

Zilog's universal serial communication controller, the USC (Z16C30™), provides higher throughput than any general purpose SCC. And it does it while reducing the CPU workload 60%.



Superintegration™ and the Communications Market.

Developed as an answer to the demand for more integration than ASICs could provide, Zilog's Superintegration™ technology has resulted in a rapidly growing family of application specific standard products (ASSPs), also known as cell-based integrated circuits, or CBICs. Working CPU and Peripherals cores and cells have been combined and enhanced for specific applications, yet they use the same proven architectures and instruction sets you're already working with.

Systems designers for the communications market needed SCCs with more speed. But that meant taking performance away from the CPU. A trade-off that was not acceptable. The USC, first of a family of Superintegration SCCs, is a solution that provides enhanced performance and reliability. Consider the far-reaching benefits. Now the way is clear for even more highly integrated systems to be developed.

And consider this. Nobody has a more complete library of proven, generic cores, system cells, or I/O bolt-ons than Zilog. Nobody is better qualified to develop and deliver Superintegration parts.

More speed.

The USC is four times faster than any general purpose SCC. You get guaranteed data rates of 10 Mbits/sec. But speed is not the only USC advantage.

More CPU power.

The USC requires less attention from the system CPU. That means more power for the system. The USC's lower overhead is due to easy initialization, auto-sequencing word transfers from deep FIFOs, fly-by DMA control, and reduced latency from an efficient, chained interrupt structure.

More flexibility.

You've got two completely independent channels, as well as multi-protocol capability. Because the USC has two BRGs per channel you can transmit and receive at two different bit rates. And the USC's universal bus interface means you can cut the cost of GLU logic and expensive board real estate.

More performance.

CMOS and Superintegration™ bring more CPU power and higher data throughput. The USC carries a 12.5 MByte/sec bus bandwidth punch. Straight DMA connect and 32-byte FIFOs make the USC's systems simple, elegant and fast. Very fast.

More reliability.

With the USC you get Zilog's proven quality and reliability. Unique built-in testability features allow access to nodes and registers for testing program functionality in real time. Find out more about the USC or any of Zilog's growing family of Superintegration products. Contact your local Zilog sales office or your authorized distributor today. Zilog, Inc., 210 Hacienda Ave., Campbell, CA 95008, (408) 370-8000.

See Fax Card for Immediate Response

Right product. Right price. Right away.

ZiLOG

ZILOG SALES OFFICES: CA (408) 370-8120, (714) 838-7800, (818) 707-2160, **CO** (303) 494-2905, **FL** (813) 585-2533, **GA** (404) 448-9370, **IL** (312) 517-8080, **NH** (603) 888-8590, **MN** (612) 831-7611, **NJ** (201) 382-5700, **OH** (216) 447-1480, **PA** (215) 653-0230, **TX** (214) 987-9987, **WA** (206) 523-3591, **CANADA** Toronto (416) 673-0634, **UNITED KINGDOM** Maidenhead (44) (628) 39200, **W. GERMANY** Munich (49) (89) 672045, **JAPAN** Tokyo (81) (3) 587-0528, **HONG KONG** Kowloon (852) (3) 723-8979, **KOREA** (82) (2) 552-5401, **TAIWAN** (886) (2) 741-3125, **SINGAPORE** 65-235 7155, **DISTRIBUTORS: U.S.** Anthem Electronics, Hall-Mark Electronics, JAN Devices, Inc., Schweber Electronics, Vargas Electronics, Western Microtechnology, **CANADA** Future Electronics, SEMAD, **LATIN AMERICA** Argentina—Yel.-(1) 46-2211, Brazil—Digibyte (011) 581-1945, Semiconductores Profesionales (5) 536-1312.

CIRCLE NO. 71

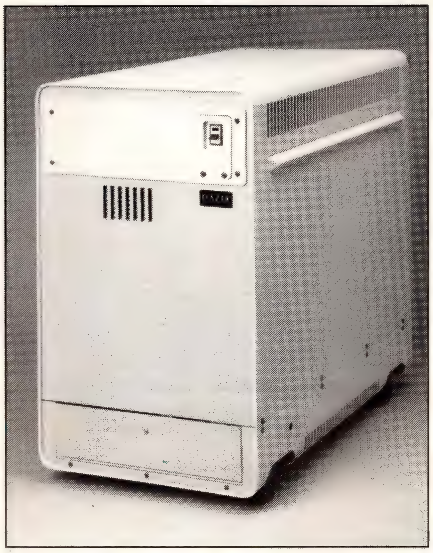
Software and parallel processing propel pc-board routing

Some engineers may see pc-board routing as black magic. And although the Voodoo Router avoids such low-tech ingredients as eye of newt and toad kidneys, its composition is the high-tech equivalent of a witch's brew—CPU boards with multiple i860s.

The $99,000 Voodoo Router is a hardware and software package that the vendor hopes is one of the products that will pull the company from its fiscal morass. A SPARCstation 1 CPU board manages the router. The board provides networking capability, is the traffic cop to the memory, and synchronizes the dedicated routing CPUs. It also converts the routing database when the database is transferred between the workstation and the Voodoo Router.

The workhorses of the router are the processor boards, which each contain two 40-MHz i860 CPUs. You can configure the router with as many as five processor boards. Each i860 CPU has a dedicated, 512k-byte, zero-wait-state coherent cache memory and 8M bytes of dedicated page-mode one-wait-state memory. An additional 32M bytes of memory is shareable among all of the router's processors. As many as four memory expansion boards, each with 96M bytes of dynamic RAM (DRAM) could ultimately give you a router with 10 CPUs and 544M bytes of shared memory.

The coherent cache memory monitors access to the shared memory by other processors. It has the capability to replace, alter, or invalidate another processor's cache memory, if necessary, to prevent the reading of bad data. The shared memory, on the other hand, holds data that all the processors might need. This data includes pad and via locations, via and block sizes, and signal identification. Data movement between all the memories and the CPUs are facilitated by a 64-bit bus.



Although this box looks innocent enough, *the Voodoo Router sticks pins and traces in the right places to route your digital pc board.*

The software algorithm that distributes and directs the routing process chooses from several routing strategies for different parts of your board. Called the Strategist, the algorithm can divide easier tasks among the CPUs at its disposal, or it can assign multiple processors to more complex tasks. The Strategist can choose from a number of different routing approaches, such as costed maze, rip up and retry, and shove aside, to yield the best routing of your board.

The router decides what is best based on your instructions. You have optional control over a number of route choices. For example, you can specify route types (single-pass placement checker, rip up, shove aside, and manufacturing pass); route grids (fixed, recommended, flexible, pattern, or separate X/Y); via grid (fixed, recommended, or separate X/Y); the use of buried and blind vias or staggered vias; 45° routing; signal-specific attributes (trace width, clearance, number of vias, types of via, and the layer on which they can appear); and layer-specific attributes (trace width, clearance, via types, and preferred pad entry).

Because the Voodoo router doesn't offer features tailored to analog design, it is best used on boards with little or no analog circuit content. The first release of the router also doesn't automatically perform gate and pin swapping. You can, however, stop and restart the batch route at any point to examine the router's progress. The software is written in C++, and the vendor anticipates that code revision and enhancements will be relatively easy.

As a network resource, the Voodoo router is accessible from any node on the network. You can offload routing jobs via Ethernet or the Network File System (NFS) protocol, allowing you to use your workstation for other tasks.

—Michael C Markowitz

Dazix, 5775 Flatiron Pkwy, Boulder, CO 80301. Phone (303) 444-8075. **Circle No. 731**

National Semiconductor

National's family of CMOS op amps rises to a new all-time low: 40 femtoamps.

TAKING IT TO THE LIMITS WITH ULTRA-LOW INPUT BIAS CURRENT.

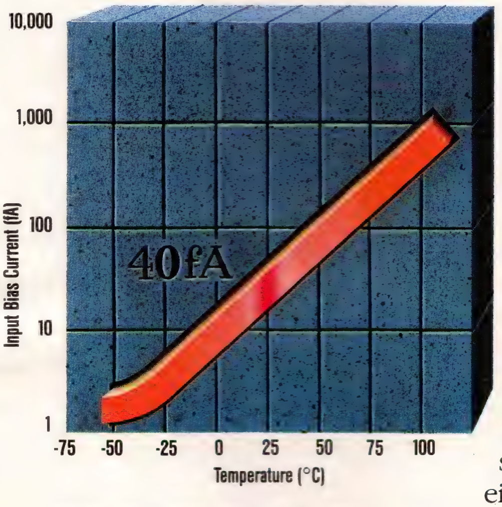
National's new quad/dual CMOS op amps, the LMC660/662 and the LPC660/662, feature an extremely low input bias current of 40 fA typical. You can't go much lower.

FEATURING RAIL-TO-RAIL OUTPUT SWING.

With a newly patented double feed-forward circuit architecture, National's op amps provide an output swing that extends from one supply rail to the other. You can't swing any more than that.

Use the LMC660/662 and LPC660/662 to drive rail-to-rail input A/Ds, or take advantage of the LMC's fully specified 600 Ω load capability to process audio in telecom and cellular radio applications. Other typical applications include:

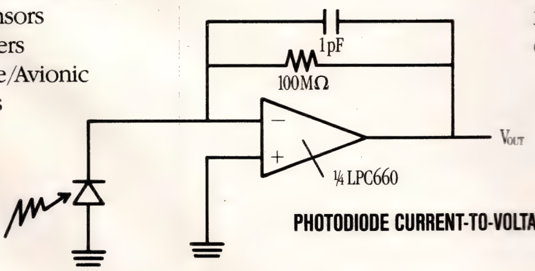
- Handheld meters
- Medical instrumentation
- Remote sensors
- Electrometers
- Spaceborne/Avionic subsystems



INPUT BIAS CURRENT VS. TEMPERATURE: 40 fA AT 25°C

NATIONAL REDEFINES SINGLE-SUPPLY OPERATION.

In the past, a single-supply op amp was an amplifier whose input common-mode range included ground. But in today's +5V systems, you need op amps that take advantage of every last volt that the supply provides, and whose outputs swing fully from rail-to-rail. National was the first to deliver rail-to-rail performance with the LMC660 and now has a complete family—all in CMOS.



PHOTODIODE CURRENT-TO-VOLTAGE CONVERTER

POWER UP WITH LOW POWER AND MICROPOWER.

If you're looking for low power, there's the LMC660/662, which operate at 375 μA/amplifier. Or if your application calls for 40 μA/amplifier, we offer the LPC660/662, micropower versions of the popular LMC series. In either case, you get lower power dissipation and a longer lasting battery.

LMC660/LPC660 VS. THE COMPETITION

	LMC660AI	LPC660AI	TLC274AI
Output Swing ($V^+ = +5V$)	**0.15V to 4.82V**	**0.03V to 4.97V**	**0.05V to 3.2V**
V_{OS} (max)	3 mV	3 mV	5 mV
I_b (typ)	40 fA	40 fA	600 fA
Supply Current (typ)	375 μA/amp	40 μA/amp	675 μA/amp

GET THE LOWDOWN.

For more information on our new CMOS op amps and growing family of high-performance amplifiers, including VIP,™ Bi-FET,™ Super-Blocks,™ and precision, call or write us today: **1-800-624-9613, Ext. 66. In Canada: 1-800-548-4529, Ext. 66. National Semiconductor Corporation, P.O. Box 7643, Mt. Prospect, IL 60056-7643.** And find out how we can help take your designs to new heights.

National Semiconductor

Bi-FET, Super-Blocks, and VIP are trademarks of National Semiconductor Corporation.
© 1990 National Semiconductor Corporation

CIRCLE NO. 70

Optimized ICs advance the art of analog switching by providing high performance in specific parameters. (Photo courtesy Maxim Integrated Products; photography by Dannetta K Lampreda)

ANALOG SWITCHES & MULTIPLEXERS

Doug Conner, *Regional Editor*

High-performance analog switches and multiplexers save pc-board space and give you more options when switching high-voltage and wideband signals.

By minimizing the number of components you need to use, high-performance analog switches and multiplexers can simplify your circuit design. For example, a device with built-in overvoltage protection ensures that you won't have to add components that degrade switch performance. Also, higher-performance switches can preserve system-performance parameters that are difficult to maintain, such as system bandwidth, accuracy, or total harmonic distortion (THD). A monolithic switch may satisfy an application that previously required a relay or switch built from discrete transistors; in addition to using less pc-board space, the monolithic device is often less expensive than comparable discrete designs.

The switching-performance specifications of analog switches are improving slowly but steadily. The latest devices may feature low leakage current, high bandwidths, or high voltages—but not all of these goodies in one switch. **Table 1** shows which manufacturers offer switches in which category: low-leakage, high-voltage, overvoltage-protected, wideband, crosspoint, or general-purpose switches.

It's difficult and expensive to attempt to provide top performance in all parameters in an individual switch, so manufacturers optimize switches and multiplexers for specific applications. In other words, each switch makes performance tradeoffs, exchanging high performance in certain characteristics for higher performance in other specs. For example, Siliconix uses a performance equation to compare the performance of their various analog switches: the performance product equals a constant divided by the product of the on-resistance, leakage current, switching time, and power dissipation. For a given performance product, the manufacturer juggles parameters to optimize a switch in one feature while making others worse. For example, if you need to reduce leakage current, you may elect to accept a higher on-resistance.

Table 2A shows some of the performance limits of spst analog switches. Competitive devices often have very close specifications; many manufacturers offer similar approximate performance levels.

One of the advantages of most of the latest high-performance analog switches is that you usually get full compatibility with TTL and CMOS control-voltage levels. Many older products not only have overvoltage and latch-up problems, but also they aren't always fully compatible with TTL and CMOS

The latest high-performance analog switches usually provide direct compatibility with TTL and CMOS switching levels.

levels. For example, older switches that claim TTL compatibility often require the use of a resistor to pull up the TTL outputs to 5V.

Even with newer analog switches, you might need to use level translators to boost control-logic levels to 15V. Supertex's HV22, fabricated using a high-voltage CMOS/DMOS process, can switch 140V p-p signals and requires 10-to-15V CMOS logic levels. Maxim's Max340 family of high-voltage switches also requires level translators.

If you need wideband rather than high-voltage performance, you'll find a wide selection of devices. Wideband devices and general-purpose analog switches have certain differences other than signal bandwidth. For example, both bidirectional switches and unidirectional bipolar devices are available. For these bipolar devices, on-resistance isn't a consideration. Instead, you'll want to look at input impedance, output drive impedance, and offset voltages.

T switches for high bandwidths

As you increase the signal bandwidths on analog switches and multiplexers, the maintenance of acceptable off-isolation and crosstalk levels requires architectural changes by the IC manufacturer. Switches that use a conductive path to link the input and output (usually CMOS or DMOS devices) normally replace the single switch structure with a T switch structure, as shown in **Fig 1**.

T switch configurations increase off isolation and reduce crosstalk by routing the capacitive coupling of the off channels to ground. This technique improves the off isolation and crosstalk at the expense of greater on-resistance, which is caused by the two switches in the signal path, and more stray capacitance. In spite of the greater on-resistance and the greater capacitive coupling to ground, the result is better overall performance for wideband applications.

When considering the tradeoffs between bipolar and CMOS technologies for wideband-switching applications, one usually assumes that a bipolar switch will consume more power. Bipolar devices usually do consume more power, but you need to consider the entire circuit design.

Unlike a bipolar switch, a CMOS switch usually requires an output buffer amplifier. Because it doesn't need this extra component, the bipolar switch can help save power. CMOS and DMOS switches usually require two buffer amplifiers—one for the input and one for the output. Wideband buffer amplifiers consume a lot of power, and they may not be necessary with bipolar switches and multiplexers, because these devices usu-

Table 1—Manufacturers of analog switches and multiplexers

Manufacturer	General purpose		Low leakage (<2 nA max at 25°C)		High voltage (> 40V p-p signals)		Overvoltage protected		Wideband (75-MHz bandwidth)		Crosspoint switches
	Switches	Multiplexers	Switches	Multiplexers	Switches	Multiplexers	Switches	Multiplexers	Switches	Multiplexers	
Analog Devices	•	•	•	•			•			•	
Burr-Brown		•		•				•		•	
Datel		•		•						•	
Fujitsu	•										
Gennum									•	•	•
Harris	•	•	•	•		•		•	•	•	•
Maxim	•	•	•	•	•			•	•	•	
Mitel											•
National Semiconductor	•	•									
NEC											•
Precision Monolithics	•	•	•	•			•	•			
SGS—Thomson											•
Silicon Systems											•
Siliconix	•	•	•	•					•	•	•
Supertex					•		•				
Texas Instruments	•	•									

ally have a high input resistance and a low output resistance.

Analog Devices' AD9300 is a high-performance, wideband bipolar multiplexer. The monolithic 4:1-channel multiplexer has a 350-MHz small-signal bandwidth and a 34-MHz full-power bandwidth. The outputs of the IC go into a high-impedance state when the multiplexer is disabled, so it's possible to parallel or cascade multiple ICs without degrading the performance. The multiplexer also exhibits 0.1-dB flatness to 8 MHz. Input resistance is typically 3 MΩ, and output resistance is typically 9Ω. The multiplexer costs $8 (100).

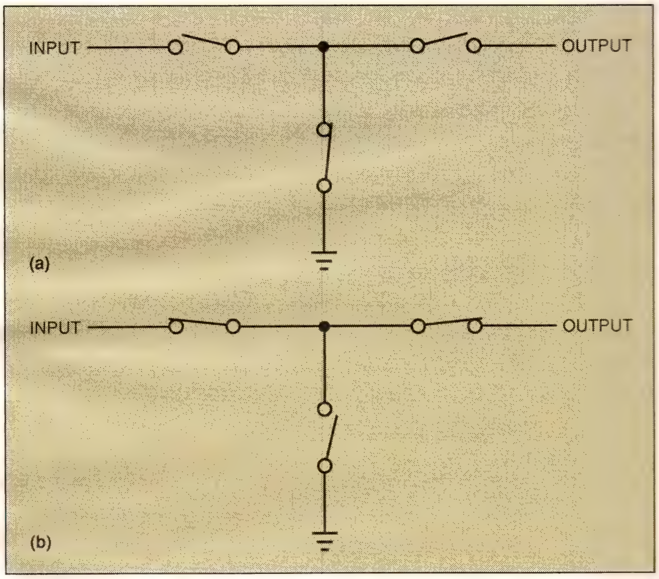


Fig 1—A T switch in the off state (a) shunts capacitively coupled signals to ground, increasing off isolation and reducing crosstalk. In the on state (b), a T switch has greater capacitive coupling to ground and greater on-resistance, because there are two switches in series.

Like switch manufacturers, manufacturers of wideband multiplexers use a bipolar process and both CMOS and DMOS processes. In the lower-bandwidth multiplexers, CMOS processes dominate. The important parameters for the lower-bandwidth analog multiplexers are the leakage current, the on-resistance, the power consumption, and the analog-signal range. In some applications, fault protection for overvoltage conditions is also important.

Table 3A shows the performance limits of 8:1 analog multiplexers. Many of the manufacturers offer similar performance levels.

Most multiplexers are of the break-before-make vari-

Table 2A — Performance limits of spst analog switches

Description	Specification (max at 25°C unless noted)	Device	Manufacturer
On-resistance	10Ω	DG180	Siliconix
Leakage current, source off	0.25 nA	DG411	Siliconix
Leakage current, drain off	0.25 nA	DG411	Siliconix
Leakage current, drain on	0.4 nA	DG411	Siliconix
Analog-signal range	±70V	HV22	Supertex
Turn-on time	25 nsec	GY4102[1]	Gennum
Turn-off time	25 nsec	GY4102[1]	Gennum
Charge injection	1 pC	DG441	Siliconix
Typical bandwidth	500 MHz	DG540	Siliconix
Off isolation	95 dB at 30 MHz	GX4201	Gennum
Power consumption	0.035 mW	DG401	Siliconix

Notes: 1. spdt

Table 2B — General specifications of spst analog switches

Manufacturer	Device	Number of switches	On-resistance (Ω, max at 25°C)	Output leakage (nA, max at 25°C)		Recommended analog-signal range (V)	Switching time (nsec, max at 25°C)		Price (100)
				on	off		on	off	
Gennum	GY4102[2]	1	NA	NA	NA	−2.5, +3.5	25	25	$6.50 (1000)
	GX4201	1	NA	NA	NA	−2, +3	400	1000	$1.32 (1000)
Siliconix	DG180	2	10	—	10	±10	300	250	$9.91
	DG411	4	35	0.4	0.25	±15	175	145	$2.52 (1000)
	DG441	4	85	0.5	0.5	±15	250	120	$1.45
	DG540	4	60	10	10	−5, +8	70	50	$3.93
Supertex	HV22	8	20	10,000	—	140 p-p	2000	3000	$21.37

Notes: 1. Prices are for least expensive commercial versions, which may not meet all specifications in the table.
2. spdt
3. NA = not applicable

Maintaining acceptable off-isolation and crosstalk levels at high bandwidths requires architectural changes by the IC manufacturer.

ety, because this type will prevent you from shorting two inputs. If your design calls for placing numerous multiplexer ICs or multiple-switch ICs in parallel, examine the specifications and your circuit carefully to be sure you're satisfying the break-before-make conditions.

Table 3A — Performance limits of 8:1 analog multiplexers

Description	Specification (max at 25°C unless noted)	Device	Manufacturer
On-resistance	90Ω	DG538	Siliconix
Leakage current, source off	0.01 nA	Max328	Maxim
Leakage current, drain off	0.02 nA	Max328	Maxim
Leakage current, drain on	0.05 nA	Max328	Maxim
Analog-signal range	±50V	IH9108	Harris
Safe signal range, power on	±60V	Max378	Maxim
Safe signal range, power off	±75V	Max378	Maxim
Transition time	50 nsec	MX826[1]	Datel
Switching time, on	50 nsec	MX826[1]	Datel
Switching time, off	50 nsec	MX826[1]	Datel
Power consumption	0.115 mW	IH9108	Harris
Off isolation	110 dB at 10 MHz	6X434[2]	Gennum
Ouput settling time, 10V step to 0.01%	225 nsec	MX826[1]	Datel
Typical bandwidth	500 MHz	DG538	Siliconix

Notes: 1. Hybrid multiplexer
2. 4:1 multiplexer

On the other hand, certain applications require make-before-break switching. An example is when you switch between gain-setting resistors in a programmable-gain circuit for an op amp. If you use break-before-make switching, the amplifier would run in an open-loop mode during the switching period, with the output slewing to the positive or negative supply voltage. Make-before-break switching would be a better choice for this application because it would provide a smooth change from one gain value to the next.

Whether you're using analog switches, multiplexers, or crosspoint switches, matching on-resistance between different channels can be very important, especially for dynamic signals. You can usually design your circuit to accommodate signal attenuation and phase shift caused by on-resistance. If, however, the attenuation and phase-shift changes between channels are too high, the performance of your system will suffer.

Consider leakage effects

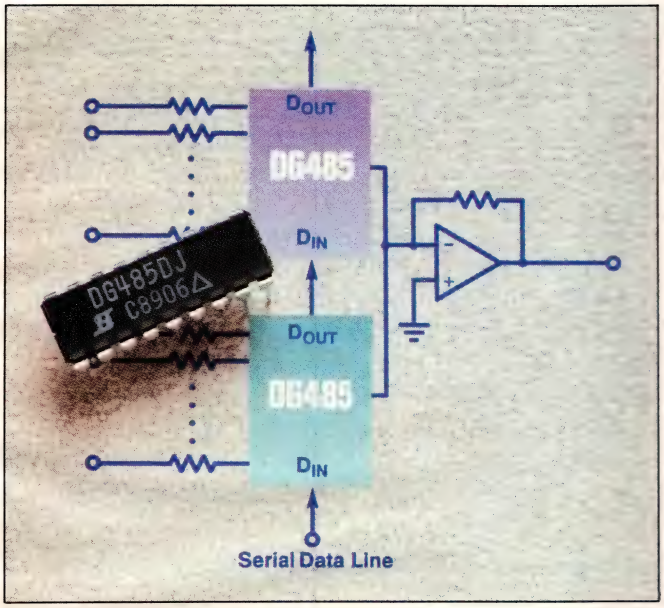
When you're designing with multiplexers, leakage current can contribute significantly to errors, especially if you're using high-impedance sources or using small currents in general. Avoid situations where the leakage current becomes a significant source of error. If you're multiplexing voltages, you can scale them to a higher voltage. For example, a leakage of 100 nA through a 200Ω switch contributes only a 20-mV error. If you've scaled your maximum voltage to 20V, then you have a dynamic voltage range that spans 6 orders of magnitude.

On the other hand, if you're multiplexing currents, you might scale them so that 1 mA is your maximum

Table 3B — General specifications of 8:1 analog multiplexers

Manufacturer	Device	On-resistance (Ω, max at 25°C)	Output leakage (nA, max at 25°C)		Recommended analog-signal range (V)	Switching time (nsec, max at 25°C)		Price (100)
			on	off		on	off	
Datel	MX-826	NA	NA	NA	±10	50	50	$100 each
Gennum	GX434[2]	NA	NA	NA	−1.2, +2	400	940	$4.32 (1000)
Harris	IH9108	120	20	25	±50	2000	1000	$25.45
Maxim	Max328	2500	0.050	0.020	±15	1000	1000	$5.90
	Max378	3000	2.0	1.0	−12, +13.5	1000	1000	$13.31
Siliconix	DG538	90	20	20	−5, +8	300	150	$11.73

Notes: 1. Prices are for least expensive commercial versions, which may not meet all specifications in the table.
2. 4:1 multiplexer
3. NA = not applicable



Useful for current-summing applications, *the DG485 from Siliconix lets you connect any combination of eight inputs to a common output.*

current. A 200Ω on-resistance would cause a 200-mV drop through the switch, but the leakage current would cause the error. Using the same 100-nA leakage current, your circuit would have a dynamic current range that spans 4 orders of magnitude.

In certain applications, it's not practical to scale voltages or currents that are going through multiplexers. For example, if you're multiplexing inputs from high-impedance sensors, it would be expensive to buffer and scale each input before multiplexing, especially if you're using differential measurements. If it's impractical to scale voltages or currents to minimize the effects of leakage current, then you need to examine the leakage specification carefully and perhaps look for a low-leakage multiplexer.

Most multiplexer applications route signals from multiple sources into an A/D converter. If you're trying to quickly measure the voltage from every source, you need to minimize the time spent on each channel. However, after the multiplexer switches, each channel needs a certain amount of time to settle, and no high-speed S/H amplifier and fast A/D converter can eliminate this necessary settling time.

Often, the settling time of the multiplexer is the major contributor to the overall settling time of the circuit. Also, it's important to remember that any capacitance on the output of the multiplexer will further increase the settling time.

Datel's MX-826 8:1 hybrid multiplexer is the first multiplexer to specify a 0.003% settling time of 400 nsec with a 10V step. The device has an input impedance of 2.5 kΩ. Its amplifier has a gain of −1 and provides a dc output impedance of 0.1Ω. The device's 8-MHz small-signal bandwidth makes it suitable for high-speed data acquisition and other wideband applications.

The MX-850 4:1 hybrid multiplexer, newly released by Datel, pushes performance even higher. The 100-MHz MX-850 settles in 50 nsec to 0.01% and 100 nsec to 0.001%. The device costs $116 (100).

Avoid instant destruction

Overvoltage problems have plagued CMOS multiplexers for years. The culprits are signal voltages that exceed the IC's power-supply voltages. Three main overvoltage problems can occur. First, in many multiplexer applications, you have to route signals over long distances. The long lines connecting to the multiplexer can pick up voltage spikes through capacitive or inductive coupling. At worst, these voltage spikes can cause overvoltage damage.

The second—and probably more common—overvoltage problem is the possibility that signals will arrive at the multiplexer while its power is off. The multiplexer's power may be off because its power supply has been inadvertently shut down, because its power supply has failed, or because the signal source was switched on before the multiplexer. At any rate, on many CMOS analog multiplexers and switches, the presence of analog signals that exceed the power-supply levels means instant destruction (see the **box**, "Protecting CMOS switches from overvoltage damage").

The third overvoltage problem crops up if a fault in the system has caused an overvoltage to occur at the input to the multiplexer. In some cases, you'll want to ignore overvoltage faults, but in a high-reliability system or in cases where an overvoltage fault is likely to occur, you may want your design to accommodate the fault case.

Fault-protected (or overvoltage-protected) multiplexers can save you from the above disasters. Fault-protected multiplexers specify an analog-signal operating range that's typically around 30V p-p, and their fault-protection range may go as high as ±60V, as in the case of Maxim's Max378. When the power supplies are off, the Max378 can withstand ±75V continuously.

When you exceed the normal analog-signal operating range, fault-protected devices either clamp the signal

Don't assume bipolar switches are going to cost a penalty in power.

at a safe voltage, or—in the case of the Max378—the multiplexer shuts off the overvoltage channel, allowing only a few nanoamperes of leakage current to flow. By shutting off the channel rather than clamping the signal and using a resistor to limit current, you avoid excessive power dissipation.

On fault-protected devices, pay special attention to both the power-on and power-off fault-protection ranges, and note whether the fault protection is for continuous or temporary overvoltage.

Crosspoint switches offer flexibility

Crosspoint switches fall outside the traditional domain of switches and multiplexers. Manufacturers continue to offer more analog crosspoint switches with performance improvements. Because the unique architecture of analog crosspoint switches lets you connect any input to any output in a matrix, these switches suit applications outside the traditional telecommunications and video applications.

Certain architectural differences in analog crosspoint switches may be important to your application, and you should consider these characteristics in addition to the standard product specifications.

The DG884 300-MHz 8×4 crosspoint switch from Siliconix offers double-buffered TTL-compatible latches with readback, a feature that lets you read the configuration you've loaded into the switch. The double buffer lets you take your time loading the next complete configuration for all switches and lets you simultaneously change the configuration across all switches. You can use this parallel-loading feature across multiple ICs to synchronize the switching of many channels and minimize the dead time for reconfiguring the

Protecting CMOS switches from overvoltage damage

If you're designing with CMOS analog switches or multiplexers that don't specify overvoltage-protection levels and safe analog-signal levels when power is off, consult the manufacturer or be ready to assume the worst.

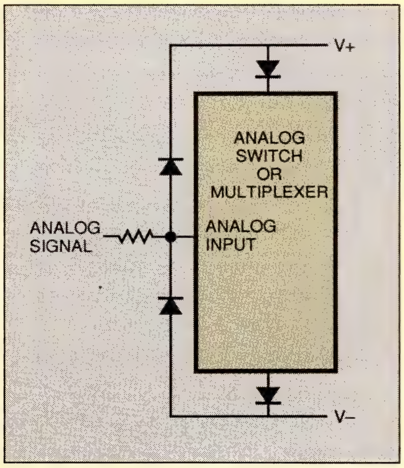


Fig A—Clamping diodes on the input *prevent the signal from exceeding the voltage of the analog switch's or multiplexer's power-supply pins. Size the resistor to limit current through the clamping diode to a safe value for the diode. Use signal diodes to minimize leakage.*

Ask yourself two questions concerning the sources of overvoltage damage: First, will I need to protect the multiplexer from signals greater than its normal operating-voltage range? Second, do I need to protect the device from analog signals that are present when the power supplies are off?

Most analog-switch and multiplexer manufacturers supply application notes on protecting against overvoltage conditions if you request them. A few general protection methods are often useful. Before you use any protection method, however, make sure you verify that it won't exceed your particular device's operating limits.

The most rugged form of overvoltage protection is illustrated in **Fig A**. You have to size the resistor for appropriate power dissipation and limit the current of the anticipated maximum overvoltage to a reasonable level for the clamping diode. You should use low-leakage signal diodes.

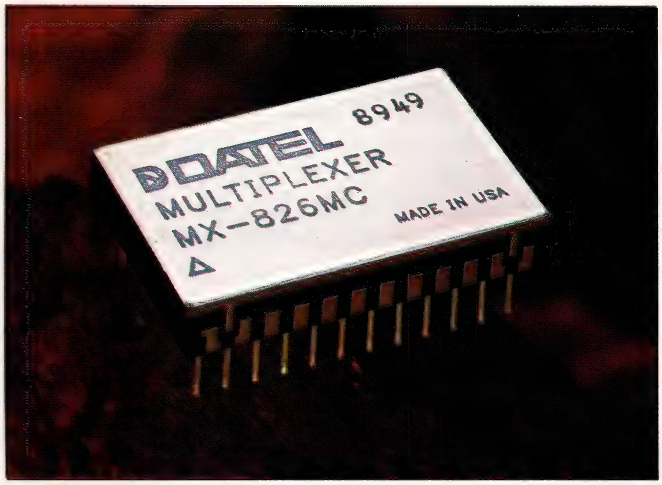
This protection method assumes that the power-supply rails act as a low-impedance source with the power off. If the power supplies could fail as an open circuit (such as a blown fuse), this protection method wouldn't work.

The overvoltage-protection scheme in **Fig A** compromises the performance of the switch in several ways, however. The added series resistance increases the effective on-resistance of the switch. The clamping diodes increase the leakage current. An additional diode drop on the power-supply rails reduces the analog signal's voltage range. However, the only way you can destroy an analog switch through the analog-signal line using this protection scheme is to exceed the maximum current-handling capability of the switch. You can avoid this problem by sizing the switches. The switch costs $23.45 (100).

Gennum's GX434 100-MHz, bipolar 4×1 crosspoint switch is glitch free during switching because of its make-before-break design. Unlike a CMOS or DMOS switch, where a make-before-break design would short the two inputs, the unidirectional transmission path of a bipolar switch simply combines the two outputs, having little effect on the inputs. The unidirectional transmission path of the bipolar design also keeps the output-to-input isolation high. The switch costs $4.32 (1000).

If you need to handle a large volume of channels, you can obtain analog crosspoint switches with as many as 8×16 channels. Mitel's MT8816 has 8×16 channels and costs $6.53 (1000).

If you have a design problem that isn't satisfied by standard switch and multiplexer configurations, you



***Datel's MX-826 8:1 hybrid multiplexer** is the first multiplexer to specify a 0.003% settling time of 400 nsec with a 10V step.*

---

series resistor to limit the maximum current through the switch.

Fortunately, in most cases you don't have to resort to complex schemes that compromise performance. When confronted with a signal that exceeds the supplies, most analog switches and multiplexers act as forward-biased diodes to the supply pins, as shown in **Fig B**. A series resistor in the analog-signal line can provide current limiting to levels that are suitable for the analog switch. The method shown in **Fig B** increases the on-resistance but doesn't affect the leakage current.

If your anticipated faults include only the signals that are present while the power supplies are off, you may be interested in the protection scheme shown in **Fig C**. The external diodes allow the device to float above the power supplies if the analog signal exceeds the power-supply rails. However, if the analog-signal voltages ever exceed the maximum voltage specification of the device, the device will be destroyed.

The method shown in **Fig C** won't protect your IC from overvoltage problems, but it also won't compromise the performance of the switch or multiplexer other than by limiting the analog-signal range by one diode drop on each supply. Combining the techniques in **Figs B** and **C** won't provide overvoltage protection.

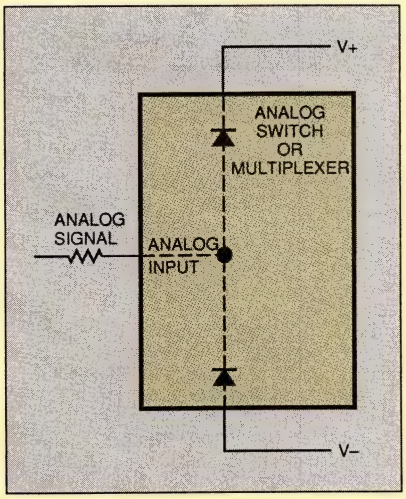


***Fig B—Many analog switches and multiplexers act like forward-biased diodes** to the supplies when analog signals exceed the power supplies. A series resistor limits currents to safe levels for the device.*

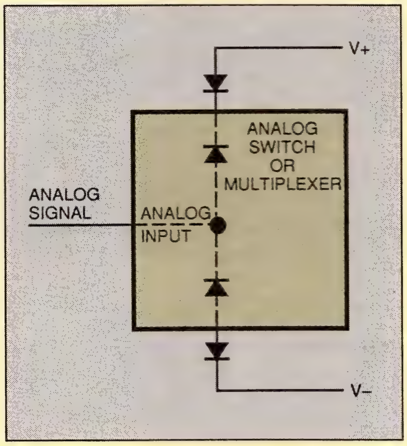


***Fig C—Adding series diodes to the power supplies** protects most CMOS switches from damage caused by analog signals that are present when the switches' power supplies are off. If analog inputs exceed the power-supply rails, the external diodes isolate the device, allowing it to float above the power supplies.*

The unidirectional transmission path of bipolar crosspoint switches keeps the output-to-input isolation high.

may find a special product that's designed to handle your problem.

For example, Siliconix offers the DG485, which routes any combination of eight signals to an output ($6.66 (100)). Unlike a standard multiplexer, you can connect more than one source at a time. You can use the DG485 to selectively switch multiple current sources for summing with an op amp.

If you need to switch high-quality audio signals, consider the SSM2402 dual analog T switch from Precision Monolithics ($3.53 (100)). Instead of using the T switch architecture to provide better isolation at megahertz bandwidths, this T switch architecture provides extremely high off isolation (120 dB) at audio frequencies (20 KHz).

You may not be impressed by the SSM2402's rate-limited 10-msec switching speed. However, this low speed does have an advantage: it avoids any audible click in the audio signal. In addition, the THD of the SSM2402 is less than 0.01% from 20 Hz to 20 kHz.

When you require high performance but you only need to switch between a few channels, don't overlook switched-input op amps. For example, the 2-channel OPA676 from Burr-Brown has a 185-MHz bandwidth for gain of 10. The settling time for a 0.625V step to 0.01% is 25-nsec typ. Both inverting and noninverting inputs switch between two channels in 6 nsec. An ECL version, the OPA675, switches in 4 nsec. The op amps cost $22.80 each. **EDN**

Reference

1. Swager, Anne Watson, "Crosspoint-switch ICs enter digital domain," *EDN*, February 16, 1989, pg 75.

Article Interest Quotient (Circle One)
High 497 Medium 498 Low 499

For more information . . .

For more information on analog switches and multiplexers such as those described in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

Analog Devices
Box 9106
Norwood, MA 02062
(617) 329-4700
TWX 710-394-6577
Circle No. 650

Burr-Brown Corp
Box 11400
Tucson, AZ 85734
(800) 548-6132
FAX 602-741-3895
Circle No. 651

Datel Inc
11 Cabot Blvd
Mansfield, MA 02048
(508) 339-3000
FAX 508-339-6356
Circle No. 652

Fujitsu Microelectronics Inc
3545 N 1st St
San Jose, CA 95134
(800) 642-7616
Circle No. 653

Gennum Corp
Box 489, Station A
Burlington, Ontario
Canada L7R 3Y3
(416) 632-2996
FAX 416-632-2055
Circle No. 654

Harris Semiconductor
2450 Walsh Ave
Santa Clara, CA 95051
(408) 996-5000
TWX 910-338-2014
Circle No. 655

Maxim Integrated Products
120 San Gabriel Dr
Sunnyvale, CA 94086
(408) 737-7600
FAX 408-737-7194
Circle No. 656

Mitel Corp
Box 13089
Kanata, Ontario
Canada K2K 1X3
(613) 592-2122; (800) 267-6244
Circle No. 657

National Semiconductor
Box 58090
Santa Clara, CA 95052
(408) 721-5000
Circle No. 658

NEC Electronics Inc
Box 7241
Mountain View, CA 94039
(415) 960-6000
TWX 910-379-6985
Circle No. 659

Precision Monolithics Inc
Box 58020
Santa Clara, CA 95054
(800) 843-1515
FAX 408-727-1550
Circle No. 660

SGS-Thomson
Microelectronics Inc
1000 E Bell Rd
Phoenix, AZ 85022
(602) 867-6100
FAX 602-867-6102
Circle No. 661

Silicon Systems
14351 Myford Rd
Tustin, CA 92680
(714) 731-7110
TWX 910-595-2809
Circle No. 662

Siliconix Inc
2201 Laurelwood Rd
Santa Clara, CA 95054
(408) 988-8000
FAX 408-727-5414
Circle No. 663

Supertex Inc
1350 Bordeaux Dr
Sunnyvale, CA 94088
(408) 744-0100
FAX 408-734-5247
Circle No. 664

Texas Instruments Inc
Box 809066
Dallas, TX 75380
(214) 997-3455
Circle No. 665

The design tool *ISS* uses to design its design tools

At ISS we base our IC design system on a radical concept. We listen to our customers.

What we heard from customers like you helped us create an IC environment for people who make their living using CAD systems. The result was IC design tools to solve your toughest design challenges, including **Layout**, **DRCs**, **PG fracturing**, and **Plotting**.

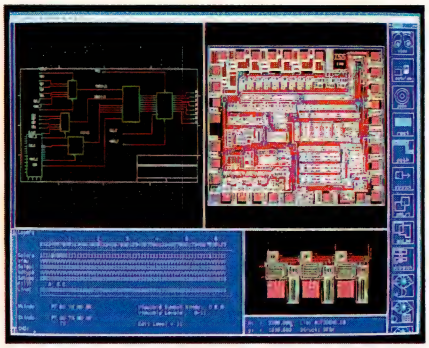
We listened when you said you needed a flexible design system. Ours lets you use a wide range of EDA tools on the leading UNIX and DOS platforms, including **Sun,™ Apollo™/HP or 386/486-based workstations.**

We listened to your ideas about user interface. With our X-window support, you can configure the user environment to your own style. Our open system accepts EDIF-standard schematics, and our C Programming Interface allows easy access to our database.

Our people know how to listen because they're IC designers themselves, who have used CAD tools to create IC designs at leading semiconductor companies.

We listened to our competition, too. We've tested our design system side-by-side with competitors' in real engineering environments and our products outperformed them in speed, ease-of-use and functionality. At a lower price.

Now that we've listened to you, why not listen to us? **Try our IC CAD tools free for 30 days** – Install them on the workstation of your choice, or visit our sales offices for a demonstration. And see for yourself how well we listen.



ISS IC CAD tools in multi-windows

ISS Integrated Silicon Systems, Inc.

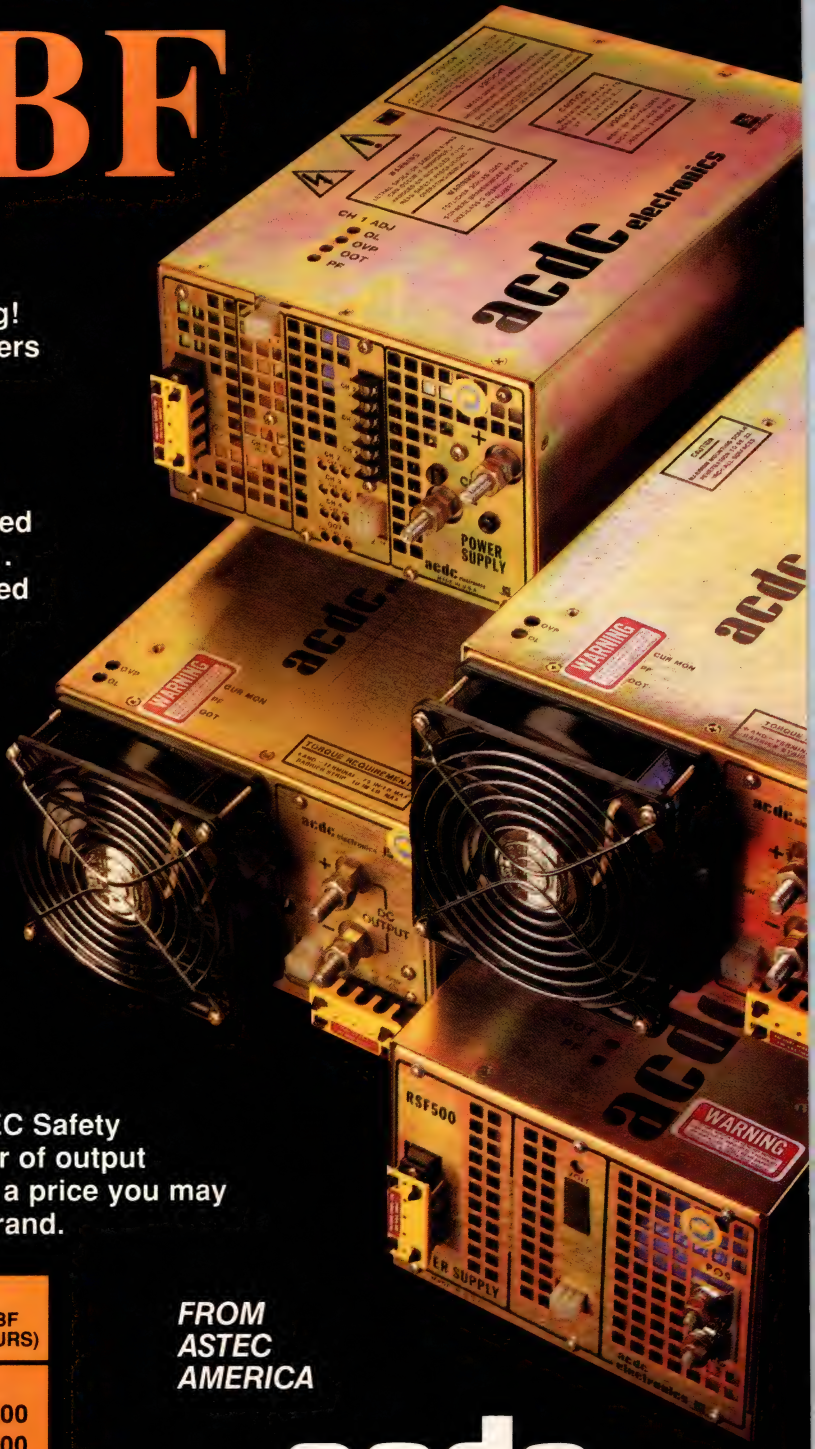
ISS. The IC CAD company that listens.

P.O. Box 13665, Research Triangle Park, NC 27709, 919/361-5814 California: 408/562-6154 Texas: 512/452-5814

UNIX is a trademark of AT&T. Apollo is a trademark of Apollo Computer. Sun is a trademark of Sun Microsystems, Inc.

CIRCLE NO. 89

500,000hrs. MTBF



That's acdc. Power Supplies built to keep working, and working, and working! Specifically, our 500 to 1500 watt switchers have MTBF numbers that literally just won't quit.

INDUSTRY LEADERSHIP

Reliability is designed in first, and verified during the development of each product. Every unit is manufactured with controlled processes, thoroughly computer tested and burned-in at full load (40°C with 60 second AC cycling for up to 48 hrs.), acdc builds supplies like nobody else.

The result is this...exceptionally high MTBF performance demonstrated in the field, setting the new industry standard for reliability.

GREAT FEATURES... GREAT PRICE!!!

Of course our supplies meet UL, CSA, IEC Safety Specs and can be ordered in any number of output configurations. All this performance for a price you may already be paying for a not-so-reliable brand.

OBSERVED MTBF			
MODELS	POWER	UNITS	MTBF (HOURS)
SINGLE'S			
RSF501	500W	9,000	877,000
JF751	750W	8,000	448,000
JF101	1000W	11,000	403,000
JF151	1500W	3,000	400,000
MULTI'S			
RSF504	500W	8,000	346,000
REV804	800W	10,000	365,000

acdc has maintained a complete database of shipments and returns since 1985. Observed MTBF statistics are calculated per MIL-STD-781.

FROM ASTEC AMERICA

acdc electronics

401 JONES ROAD, OCEANSIDE, CA 92054
TEL: 619-439-4200 FAX:619-439-4243

CIRCLE NO. 90

Sierra C For The 68000 Family Creates The Four Second Coffee Break

Those endless compile-time coffee breaks are a thing of the past.

Compiles Faster

The Sierra C™ compiler gets your code into your target system 10 to 20 times faster than other high performance compiler packages. The dhrystone benchmark, on a 16 MHz PC AT® host, compiles, assembles, links and downloads to a 68020 target in less than 4 seconds.

Generates Better Code

Sierra C has resolved the paradox of fast compiles and optimized code. While compiling at blazing speeds, Sierra C generates faster and tighter code than any other optimizing compiler on the market today.

Complete Development Toolset

Sierra C is more than fast—it's complete. It includes all the tools you need for cross-development, built to perform with unsurpassed efficiency. Along with Sierra C's optimizing compiler, macro assembler, and linker/locater, you get a librarian, symbol table examination utilities, a high speed parallel download system and a multi-window source level debugger. Complementing the toolset is an extensive C runtime library supplied in both source and object form.

Designed for Embedded Systems

Sierra C conforms to the proposed ANSI C standard, supporting function prototypes and the important keywords *const* and *volatile*. Position independent, re-entrant, and ROMable code can be generated. Code can be optionally grouped into as many as 126 independently positionable sections. Assembly language can be inserted into your C program through the *asm* keyword extension. And the download utilities allow executable modules to be transferred directly into the target system or into a PROM programmer with optional even/odd/quad byte selection. The Sierra C toolset supports all members of the 68000 family including the new 68332. Sierra C is available now for PC AT and PS/2™ computers, DEC VAX® systems, Sun™ Workstations and other UNIX™ systems.

With Sierra C you get better products out faster. Call today for more information at **800•776•4888**

SierraSystems

6728 Evergreen Ave., Oakland, CA 94611 (415) 339-8200

Sierra C is a trademark of Sierra Systems. PC AT and PS/2 are trademarks of International Business Machines Corp. DEC and VAX are registered trademarks of Digital Equipment Corp. Sun is a trademark of Sun Microsystems. UNIX is a trademark of AT&T.

EDN

EDN'S ALL-STAR PC PROJECT

Many avid sports fans create fantasy teams composed of their favorite players. The players' performances in actual games determine the fantasy league team scores every week. We decided to do something similar at EDN, but our team is a very real PC. We assembled our players—high-performance PC components—to find out how they would play together in reality. Many of the products we eventually picked didn't even exist at the start of this project. We call our creation EDN's All-Star PC, because each component is a stellar performer.

We had many reasons for building the All-Star PC: We needed a powerful computer to test the many CAD and CAE software products that run on PCs, because many of these packages outstrip the capabilities of garden-variety PCs.

We wanted to illustrate the PC's architectural versatility. You can now find PC-based systems and single-board computers that meet the requirements of design projects ranging from instrument controllers to complex embedded systems.

And, we built EDN's All-Star PC to help you judge the true value of the many technological developments that took place in 1989. These developments presage major changes for PCs in 1990. For example, Intel's 80486 μP redefines the high-end PC; new SCSI-based data-storage products pack away massive amounts of data in PC-class systems; and new graphics products bring workstation-class resolution and performance to PC displays.

The five articles in this series will chronicle EDN's project, explaining how and why we selected each component. We built the All-Star PC to serve as an engineering workstation and biased our decisions accordingly. You may not agree with all our product selections—even some EDN editors disagree—but at least you'll understand how we made our particular choices. We hope our experiences will help you make better choices and speed you toward your goals.

Play ball!

STEVEN H LEIBSON, Senior Regional Editor

Sculpture by Kathy Jeffers/Sculpture Photography by Chris Vincent

EDN'S ALL-STAR PC

PART 1:

GROUNDWORK

It seemed so easy. Build the World's Most Powerful PC by picking the best components and melding them into an integrated whole. But every integration is tough, and the All-Star PC takes the problems of system integration to the extreme. The selection process, with vendors offering thousands of PC components, is daunting. And even when you've picked the components you want, making them work together is no picnic.

More than one million transistors stare at me through the clear plastic fob dangling from the keys to EDN's All-Star PC. The transistors reside on an immense silicon slab and are collectively known as Intel Corp's 80486 µP. This hunk of plastic and silicon makes a fitting symbol for the hyperspatial leap in PC performance that the 80486 empowers. The µP's die measures 0.619 × 0.414 inches—an unthinkable and unbuildable IC only a few short years ago. Similarly, a personal computer with the speed and capacity of EDN's All-Star PC could not have been built without several technological developments of the very recent past. This project, to tailor a PC to the needs of the engineer, demonstrates just how far these developments have taken the PC's architecture in its first decade.

Size played a major role in selecting the project enclosure. The VES 1000 enclosure system from Interface Electronics Inc fit the project's requirements exactly.

Engineers adopted PCs long before they were called personal computers. In fact, they adopted them even before the first µPs appeared. Hewlett-Packard's 9100 programmable desktop calculator, a proto-PC that appeared in the late 1960s, was developed by the company's Loveland Instruments Div for the express purpose of controlling lab instruments. An ancillary result was that it heralded the next decade's revolution in personal computing for engineers. The 1970s saw the arrival of microcomputers based on 8-bit processors, such as Intel's 8080 and Zilog's Z80 µPs, and electrical engineers conscripted many of these machines for hardware- and software-development tasks.

The PC, as introduced by IBM in 1981, accelerated the engineering community's acceptance of the personal computer as a valuable R&D tool. In fact, PC-based software

products now dominate several categories of engineering software, such as µP software development, PLD design, and schematic capture, because the PC makes a cost-effective engineering workstation.

The early PCs, however, couldn't handle much of the tougher work assigned to engineering workstations because of memory, mass-storage, operating-system, and graphic-display limitations. EDN built the All-Star PC to explore the current limits of PC performance and to discover the differences between PCs and engineering workstations as they exist today. Simply put, the performance levels attained by EDN's experimental machine raise the ante in the war between engineering workstations and PCs.

Critics whine that the PC stifled growth in the computer industry and suppressed technological innovation over the last decade. However, a more accurate look at the computer industry, developed by talking to many component vendors, exposes the truth: the PC's sales volume provides the economic incentive that drives innovation and development in display technology, mass-storage devices, semiconductor memory, peripheral products, and even battery technology. Although PCs may not have developed the same respectable patina as workstations for engineering applications, PCs carry substantial weight in the engineering market. For these reasons, EDN deemed PC technology sufficiently important to warrant this series.

The machine's heart and soul

Fate placed Intel's 8088 µP into IBM's original Model 5151 PC. Engineers at IBM's Entry Level Systems Div liked the processor's architecture, which provided 16-bit computing power coupled with an inexpensive 8-bit bus. They also liked the µP's 1M-byte address space, which seemed titanic when compared to the 64k-byte addressing capabilities of the then-dominant 8-bit processors. Lack of software for the 8088's architecture didn't deter IBM's engineers, nor did the software dearth last long. Commercially available software packages for the PC now number in the tens of thousands; Intel estimates that this software base is worth $15 billion.

Since the fateful introduction of the IBM PC, several vendors have introduced increasingly powerful µPs that feature object-code compatibility with Intel's original 8086 and 8088. Intel designed several of these successors. Its 80486 µP is the latest product of that evolution, and became, though not intentionally, the heart of EDN's All-Star PC (see **box**, "Changing processors in midstream").

Several of the 80486 µP's features make it an excellent choice as a processor for a PC-based engineering workstation. It combines the features of Intel's 80386 µP, 80387 floating-point processor, a 4-way set-associative cache controller, and 8k bytes of cache RAM (**Fig 1**). This high integration level saves board space, reduces power consumption, and assures the system designer of a finely tuned system core. Intel fully exploited the advantages of integration by using interconnection schemes such as dual 32-bit data buses and a 128-bit bus between the cache RAM and the prefetcher. The 80486's designers also took advantage of the device's inherent parallelism. For example, the ALU and floating-point unit can operate concurrently.

To further boost its performance, the designers identified frequently used 80386 instructions by using code traces from existing programs. A 1.2-million transistor budget allowed designers to reduce the clock-cycle counts on critical instructions by replacing sequential microcode with high-speed circuitry. **Table 1** shows some results of these optimization efforts. The 80486 achieves significantly better performance than the 80386 on a clock-cycles-per-instruction (CPI) basis. In fact, the **table** shows that the 80486 can also better the CPI performance of so-called RISC (reduced-instruc-

---

Photography by The Photo Works and Steven Leibson unless otherwise noted.

tion-set computer) μPs, whose claim to fame is low CPI counts. However, with 1.2 million transistors, you could hardly call the 80486 a RISC μP.

Other 80486 features have also proven important to the overall performance of EDN's All-Star PC. The processor's prefetch unit can theoretically fetch four 32-bit instructions in five clock cycles (normal bus cycles require at least two clock cycles per bus transfer). This burst-access mode mates quite well with the capabilities of fast-page-mode DRAMs (dynamic RAMs) and reduces or eliminates the need for secondary cache memory external to the μP. The μP's paging and segmentation units provide the memory-management resources required by multiuser operating systems such as Unix. The units allow advanced PC software to extract additional performance from system resources, even when running under Microsoft's DOS. However, the interaction between the memory-management circuitry and other system components also caused a few interesting problems, as you'll see in subsequent articles.

Even supposedly minor features make the 80486 a good choice for EDN's All-Star PC. For example, the μP generates and checks memory parity, so you don't have to include parity-generation and checking circuitry in your design. Further, the 80486's clock input requires only a 1× clock signal, so you don't need to pipe 50- or 66-MHz signals around your board, as you did for 80386-based designs. The latter is a small feature that may help keep the FCC off your back. But the biggest feature that makes the 80486 the right choice for a PC-based workstation is its compatibility with the original 8088 instruction set and the 50,000 or so commercial programs that use these instructions.

By itself, even a super processor

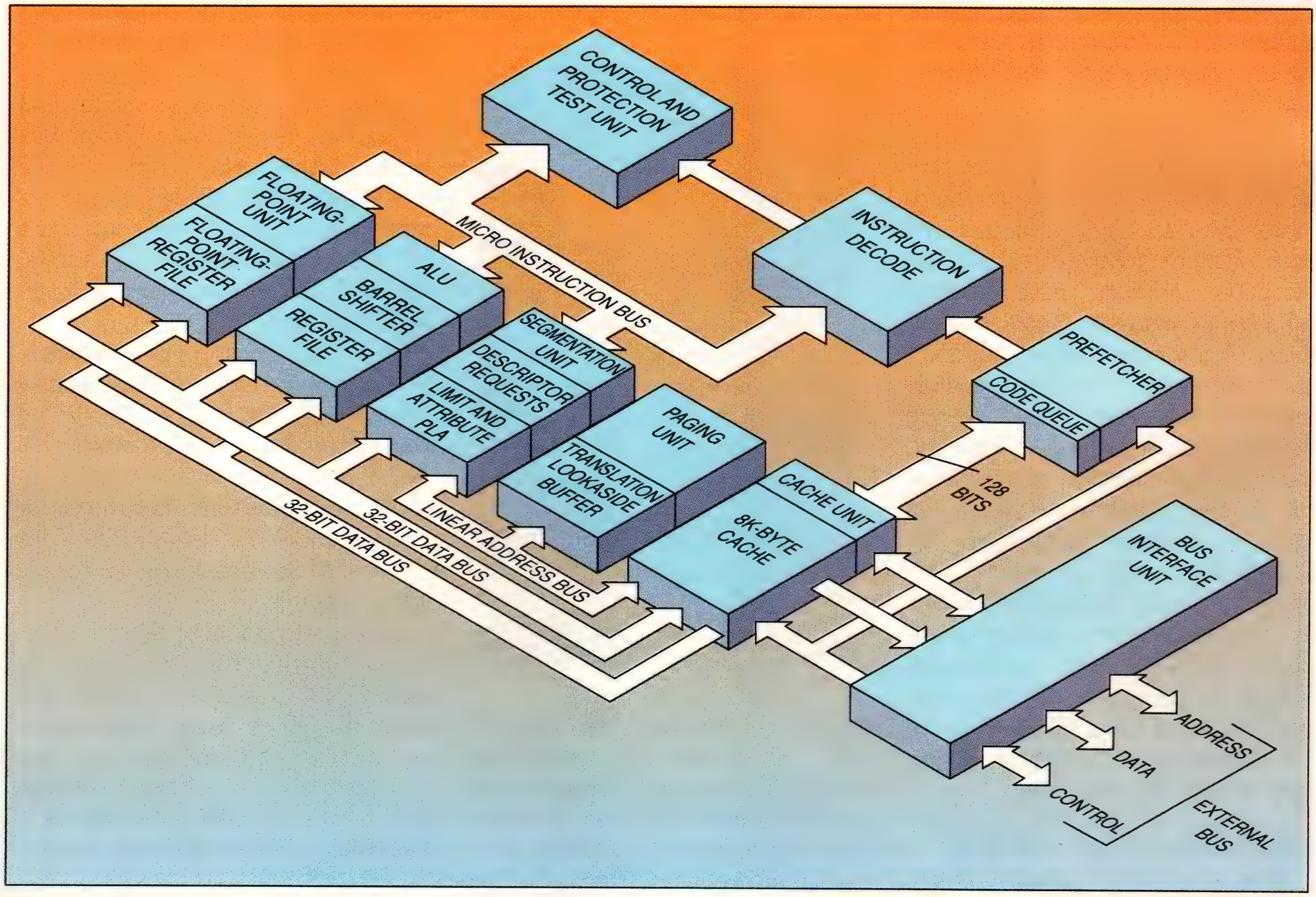
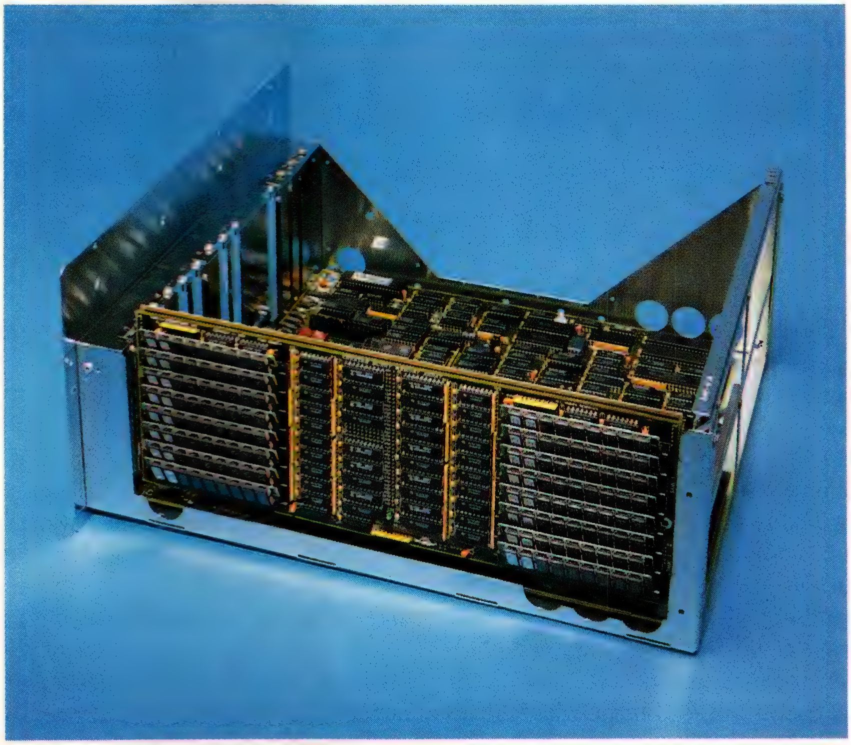


Fig 1—An integral floating-point unit and on-chip cache RAM help drive the performance of Intel's 80486 μP sky high. Massive busing moves data to the various on-chip elements quickly.



A removable card cage eases assembly and servicing of EDN's All-Star PC and provides a good display frame for the 16M bytes of RAM on the Cheetah Gold 425 daughter card.

like the 80486 isn't of much use; it has to be packaged into a system. For PCs, the key component of such a system is the mother board. Many companies make mother boards for PC systems using a variety of design philosophies. I selected the Cheetah Gold 425 mother board, from Cheetah International Inc, for the All-Star PC after several discussions with Ron Sartore, the company's president. Sartore's design strategy boils down to using the most flexible components available and wringing the last nanosecond from them without relying on "typical" specifications. That's a design philosophy I can easily accept.

As a consequence of Sartore's approach, the Cheetah Gold 425 sports PC/AT expansion slots. It doesn't incorporate any of the mother-board chip sets offered by many semiconductor vendors. Instead, Cheetah's mother board employs the same LSI peripheral devices that the PC/AT uses, glued together with PLDs. The flexibility that the mother-board PLDs provide allows Cheetah to tackle the inevitable compatibility problems that arise when plugging in various expansion cards designed for IBM's astoundingly ambiguous PC and PC/AT buses (recently misnamed the "Industry Standard Architecture" or ISA bus).

Unfortunately, IBM's entire documentation for its PC and PC/AT buses consists of a few paragraphs of text and the schematics for the IBM PC, PC/XT, and PC/AT computers. As a result of this sparse documentation, every company's implementation of these buses is somewhat different. Yet, these poorly specified, uncontrolled buses have become de facto industry standards, and as such have attracted the attention of board designers. You can't fault IBM, however. The company never proposed its PC buses as standards.

Changing processors in midstream

Cheetah's Gold 425 mother board began its existence as the Cheetah Gold/33, a design based on Intel's 33-MHz 80386 µP. I saw the board in this configuration during my first meeting with Cheetah's president, Ron Sartore. The 80386-based design placed the processor on the mother board and used a proprietary memory card plugged into a slot that was not part of the conventional expansion-slot arrangement. Because the 80386 doesn't support burst-mode transfers directly, the memory design included a burst-mode controller built from PLDs. However, by our second meeting, Sartore had converted one of the Cheetah Gold/33 memory boards into a memory- and processor-board unit based on the 80486. By pulling the 80386 from its socket on the mother board and plugging in the 80486-based daughter card, Sartore transformed his 80386-based design into the Cheetah Gold 425 in only a day or two.

Even at 25 MHz (a 25% reduction in clock rate), the 80486-based design outperformed the 33-MHz 80386-based design by a factor of two or three. The time required to remove hidden lines and regenerate a drawing of London's St Paul's Cathedral using Autodesk's popular AutoCAD program dropped from seven minutes using the 80386 to two minutes using the 80486. Clearly, the 80486's internal cache memory provides much of that performance boost (Cheetah's 80386 design employed no cache RAM), but the 80486's streamlined instructions also contribute to its speed. After Sartore's demonstration, I conscripted the 80486 onto EDN's All-Star PC Project.

The ISA bus now boasts the industry's widest range of plug-in cards. Among PC users, engineers have especially benefited from the ISA bus, because many manufacturers offer ISA boards designed especially for engineering needs. You can buy analog and digital data-acquisition cards, video frame grabbers, EPROM and PLD programmers, IEEE-488 instrumentation controllers, interface cards for nearly any digital interface ever invented, a broad range of display cards, industrial and commercial network controllers, peripheral controllers for the biggest menagerie of devices on earth, and nearly any other type of expansion card that you could possibly imagine for the ISA bus.

It will take years for these board vendors to replicate this variety for the ISA bus's successors: IBM's MCA (Micro Channel Architecture) and the EISA (Extended Industry Standard Architecture) bus. For engineers, the incessant ranting and raving in the popular PC magazines regarding the superiority of MCA or EISA is moot. Further, informed discussions regarding the advantages of multiprocessing on the MCA and EISA buses await software to exploit this capability. DOS doesn't handle multiprocessing configurations well. So until the board vendors can provide the same wide range of expansion card functions for the newer buses, I believe that the ISA bus remains the right choice for a PC-based engineering workstation. That's why Cheetah's mother board (and EDN's All-Star PC) employs PC/AT slots.

A potential flaw looms in my argument, however. If the ISA bus proves to be the limiting performance factor and actually throttles the PC's throughput, then it loses much of its attractiveness. Major consumers of bus bandwidth include the main memory, disk and network controllers, and the display adapter. Cheetah's design avoids many potential bus-bandwidth problems by separating the

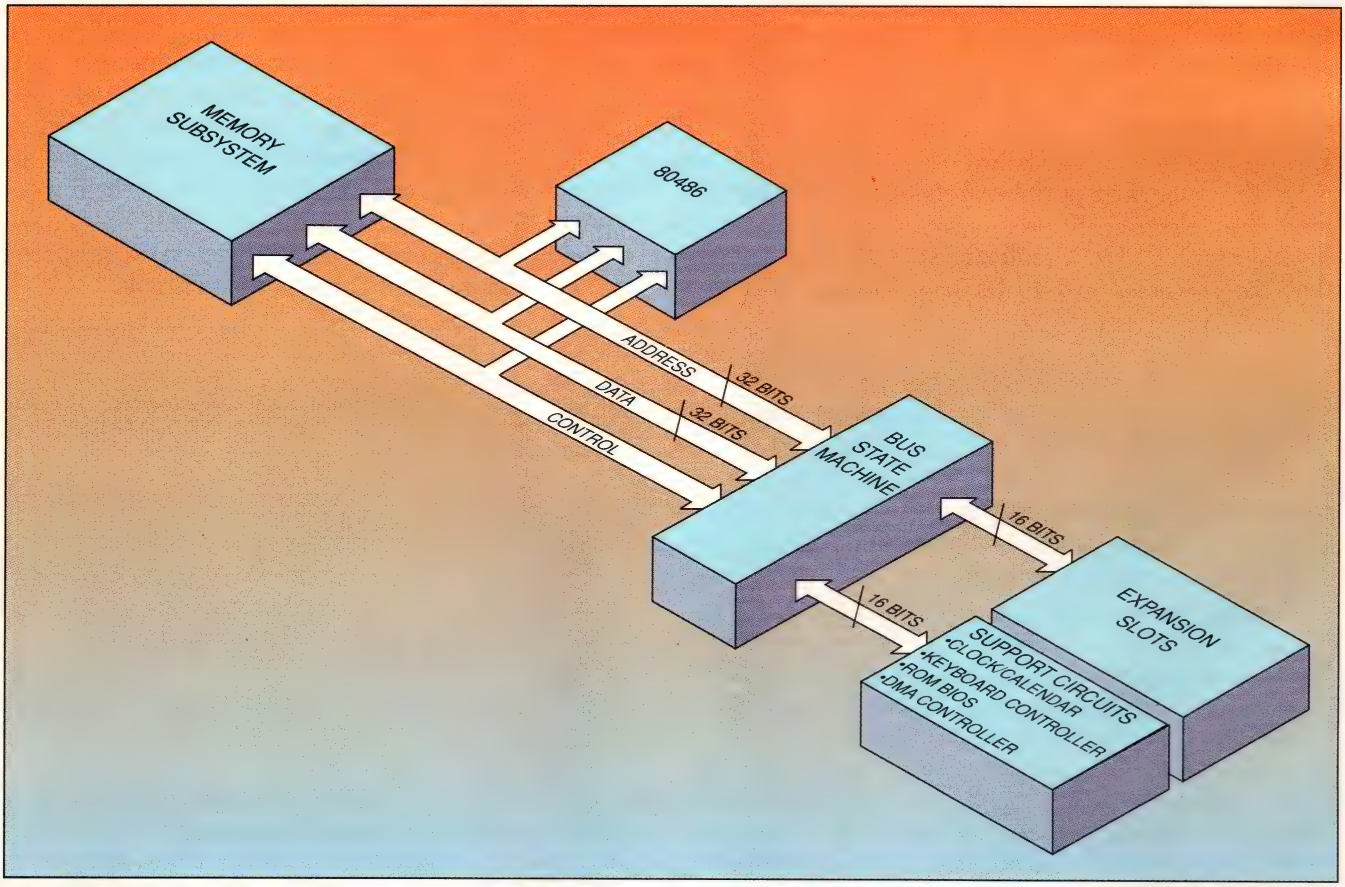


Fig 2—By separating the memory and I/O subsystems on its Gold 425 mother board, Cheetah International achieves an extra degree of parallel operation beyond that provided by the onboard 80486 μP.

main system memory and the I/O circuitry on the mother board (**Fig 2**). Both the memory subsystem and the I/O subsystem have independent, state-machine controllers that optimize the subsystems' interfaces to the 80486.

Table 1—Enhanced execution of frequent instructions

Instruction	Clock Counts			
	Intel 80386	Intel 80486	Sun SPARC	Motorola 88000
Load	4	1	2	1-3
Store	2	1	3	1
Register-to-Register	2	1	1	1
Jump (Taken/Not Taken)	9/3	3/1	1/2	1
Call	9	3	3	1

Source: Intel Corp

The processor/memory interface

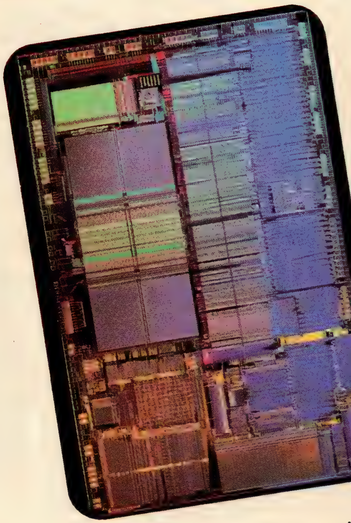
Cheetah's memory-subsystem and processor boards snap together to create a single unit, which plugs into a proprietary expansion slot on the mother board. The processor card holds the 80486 and sufficient circuitry to drive the memory controller and bus state machine. The memory card holds the entire memory subsystem, including 16M bytes of RAM, organized as four 4M-byte blocks (**Fig 3**). Cheetah's processor/memory design superficially resembles the approach taken by other vendors who build ISA mother boards for 32-bit μPs. The ISA bus doesn't support 32-bit memory, so a proprietary memory slot is required. Cheetah's approach differs by placing both the processor and the RAM on one plug-in daughter card, thereby permitting an optimized connection between the processor and memory, and removing memory cycles from the expansion bus. This approach also allows the company to migrate its design to the next μP in the PC's evolution by redesigning only the daughter card.

Because it is so closely coupled with the μP, the 425 mother board's memory subsystem achieves nearly optimum performance. With zero-wait-state RAM, the 80486 can transfer four 32-bit double words in five clock cycles. But several megabytes of zero-wait-state memory costs too much to be practical. Using fast-page-mode DRAMs, Cheetah's design can perform the burst-mode operation in six clock cycles. When loaded with 8M or 16M bytes of RAM, the memory subsystem interleaves 4M-byte memory banks and can sustain the 6-clock-cycle burst rate indefinitely if the processor continues to read memory sequentially. Without interleaving, DRAM precharge requirements

80486 μP

EDN's PC All-Stars

Intel Corp, 3065 Bowers Ave,
Santa Clara, CA 95051. (408)
987-8080. **Circle No. 666**


Intel Corp

STATS:
ALU: Optimized integer processor
FLOATING-POINT PROCESSOR: Compatible with the 80387
CLOCK RATE: 25 MHz
ON-CHIP CACHE RAM: 8k bytes
MEMORY MANAGEMENT: Page and segment units
CODE-COMPATIBLE WITH: 8086, 8088, 80286, 80386

BIO: The 80486 μP is code-compatible with its predecessor, the 80386, but runs the same code two to three times faster because of an optimized execution unit and the on-chip cache memory. A burst-access mode allows the μP to feed its prefetch unit data at 80M bytes/sec.

force the DRAM controller to insert additional wait states. EDN's All-Star PC incorporates 16 Toshiba THM91000AS-70 SIMMs (single in-line memory modules), for a total memory capacity of 16M bytes. You can also place memory in the mother board's expansion slots, but that data path runs slower because of the expansion bus's speed and 16-bit width.

Cheetah's bus state machine also attempts to minimize the consumption of bus bandwidth. All I/O devices on the mother board and all expansion cards plugged into the mother board's expansion slots transfer data in 8- or 16-bit chunks, but the 80486 has a 32-bit data bus. Intel solved this data-bus mismatch by providing the 80486 with dynamic bus sizing. For each bus cycle, the 80486 first attempts to perform the transfer using the entire 32-bit data bus. Devices that can't accommodate 32-bit bus cycles drive one of two processor pins to signal that they only support 8- or 16-bit transfers. Asserting either signal forces the 80486 to run additional bus cycles until the transfer is completed. For devices limited to 16-bit transfers, the 80486 runs two bus cycles, unless the data is not word-aligned, in which case it runs three cycles. For byte-sized devices, the processor runs four bus cycles to complete the transfer.

Nine million transistors require very little room when packaged as a 1M × 9-bit SIMM (single in-line memory module). The All-Star PC uses 16 of these 70-nsec THM91000AS-70 SIMMs from Toshiba America Electronic Components Inc.

The 80486 wastes bus bandwidth when it executes additional bus cycles to accommodate devices smaller than 32 bits. Slow I/O devices that require the insertion of wait states during a bus cycle merely compound the problem. Cheetah's bus state machine provides a partial solution to this problem by diverting write cycles into a 32-bit holding register. This register is a fast device, so it invokes no wait states. Thus, all write cycles directed at the mother board or an expansion card require only one processor bus cycle. Once the transfer between the 80486 and the holding register is completed, the processor's bus is no longer busy. Therefore, the 80486 can use the memory subsystem while the I/O controller completes the execution of the bus cycle initiated by the processor. Meanwhile, the I/O controller moves the 32 data bits from its holding register to the intended recipient of the write cycle in appropriately sized chunks using two or four transfer cycles for 16- or 8-bit devices, respectively.

Unfortunately, this clever technique doesn't work for read cycles, so the processor must throttle down to read data from devices on the mother board or from boards plugged into the expansion slots. However, the architecture must be effective for the 80486 because the Cheetah Gold 425 mother board

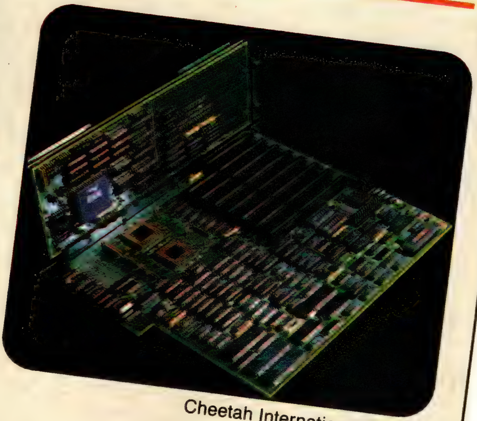
EDN's PC All-Stars

Cheetah Gold 425

Cheetah International Inc, 1003 W Cotton, Longview, TX 75604. (800) 243-3824. (214) 757-3001. FAX (214) 753-0589.

Circle No. 667

STATS:
PROCESSOR: Intel 80486
CLOCK SPEED: 25 MHz
RAM CAPACITY: 16M bytes (4M-byte increments)
EXPANSION-BUS SPEED: 6 MHz
EXPANSION-BUS SLOTS: 7
BIOS ROM: Award Software's 486 Modular BIOS


Cheetah International Inc

BIO: The Cheetah Gold 425 mother board employs state machines for its memory and I/O subsystem controllers, eking every iota of performance from the 80486 µP. It maintains compatibility with a large number of ISA expansion cards through the use of PLDs, which also allow the company to tailor the board's expansion-bus timing for special needs.

consistently outperforms other 80486-based PC mother-board designs in benchmark tests conducted by computer magazines such as *Byte* and *Personal Workstation*, formerly *MIPS* (**Refs 1** and **2**).

Cheetah's bus state machine also disassociates the mother board's expansion-bus speed from the processor's clock rate. IBM's original PCs merely extended the µP's bus signals to the expansion bus through some simple buffers. The first PC ran at 4.77 MHz; the first PC/AT ran at 6 MHz. The expansion buses in these machines consequently ran at a leisurely pace. As processor speeds rose, so did the expansion-bus speeds of the PC clones. By the time the expansion buses started running at 10 MHz, some real timing problems appeared, once again because of the undocumented and uncontrolled nature of the ISA bus. The Cheetah Gold 425's bus state machine runs the expansion bus at 6 MHz and avoids many of the timing problems that sometimes crop up between fast PCs and expansion cards.

Cheetah uses Award Software Inc's 486 Modular BIOS (basic I/O system) firmware on its mother board. Award developed its 80486 BIOS code in conjunction with Cheetah. A BIOS serves as the glue between the operating system and the hardware. It translates operating system function calls into ma-

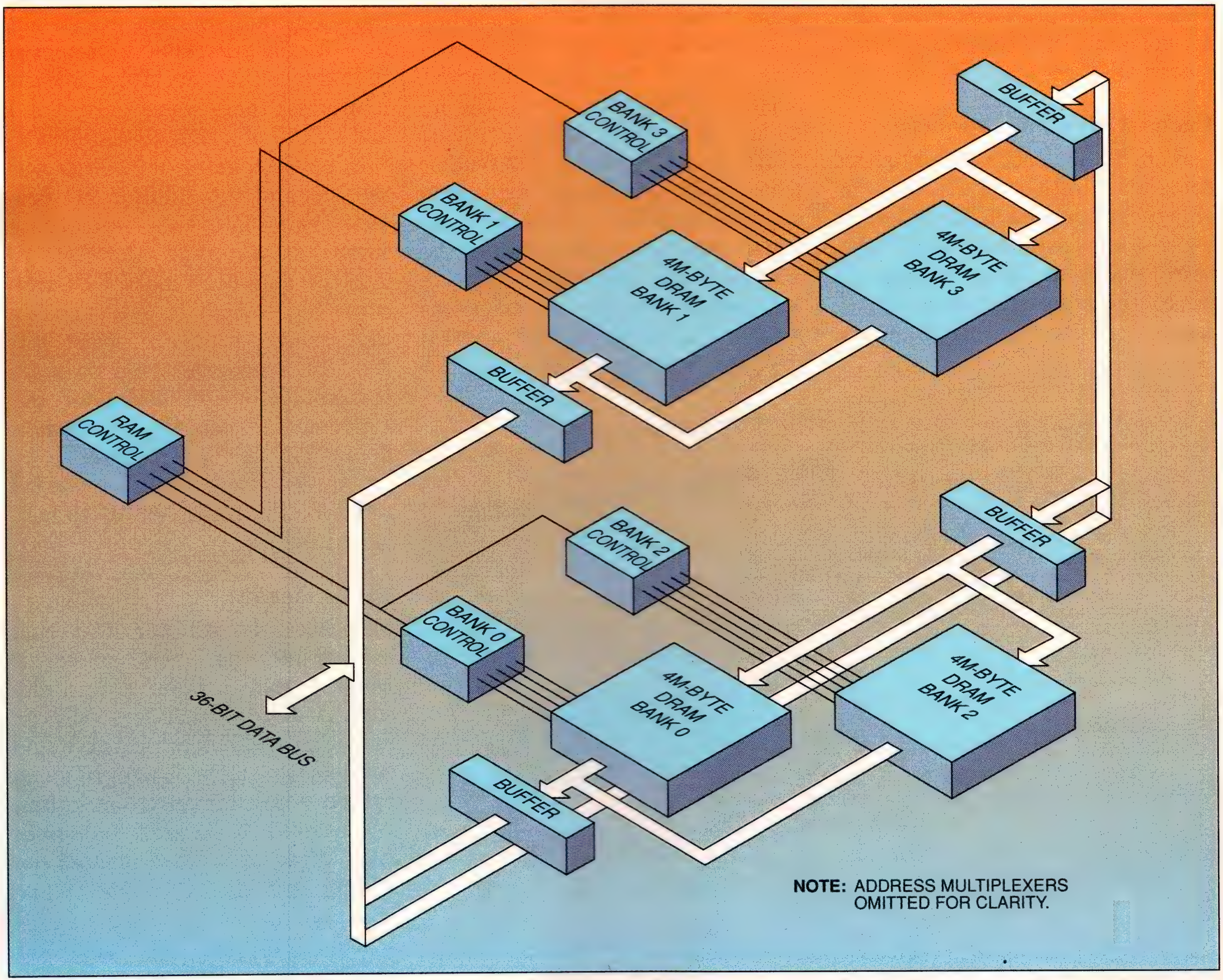


Fig 3—Four 4M-byte memory banks and independent bank-control modules permit memory interleaving in the Cheetah Gold 425 memory subsystem. This approach boosts memory throughput.

chine instructions that interact directly with the hardware. BIOS vendors must rewrite their firmware for each new µP to make the best use of the processor's new features. An 80386 BIOS will work in 80486-based systems, but it won't be able to test or use the on-chip cache memory. Because of changes made to the 80486's floating-point processor, Award modified the way in which its 486 Modular BIOS initializes the 80486's floating-point processor. The modification prevents a fatal processor error that is nonfatal in 80386/80387-based systems.

Cache RAM breaks I/O code

BIOS timing loops also required some modification. The 80486's on-chip cache memory can significantly speed the execution of looped software, and your delay timings can be considerably shortened by the faster hardware. Although Award discovered that it didn't need to make many changes to its delay code, the 80486's faster execution speed definitely caused problems later in the project.

With the mother board and processor selected, only two more components were required to complete the All-Star PC's foundation: the power supply and the enclosure for the CPU. I knew from early inquiries that I'd require a substantial power supply. My plans called for a total of seven 5¼- and 3½-in. mass-storage peripherals, including two power-hungry hard-disk drives. The largest conventional power supplies offered for PCs in the familiar AT form factor provide 250W, and most have only four or five power connectors for mass-storage devices. I doubted that 250W would be sufficient for the All-Star PC, knew that even five peripheral power connectors wouldn't be enough, and worried that the start-up-current requirements of the hard-disk drives would overload a 250W power supply's 12V output.

Fortunately, PC Power & Cooling Inc anticipated the development of large PC-based computer systems like EDN's All-Star PC and developed a 420W power supply: the Turbo 450. It supplies ample power and provides eight power connectors for mass-storage devices—perfect for the All-Star PC project. The Turbo 450 powered Cheetah's mother board in Cheetah's Colorado Springs R&D labs for a few months while I attempted to find a suitable enclosure. I knew it was out there somewhere, but I had a devil of a time finding it.

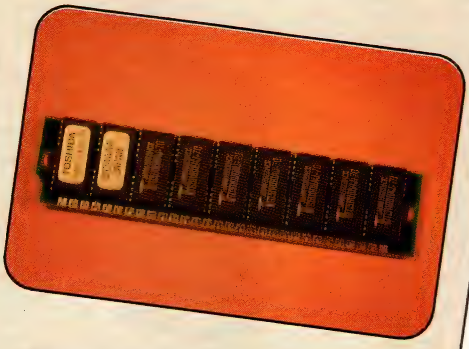
One reason for my difficulties was the scope of the All-Star PC Project. Very few PCs incorporate seven mass-storage devices, so most vendors don't make PC enclosures big enough to accommodate that many peripherals. Most AT-class PC enclosures hold no more than six half-height disk drives, but I planned to use four half-height floppy-disk drives plus three more full-height drives. Thus, I needed room for the equivalent of 10 half-height drives.

Off to Comdex

Because the All-Star PC would hold so many peripheral devices, it would require a tower-style enclosure. A desktop enclosure that can house 10 half-height drives would consume an entire desktop. Failing to find any leads on an enclosure, I journeyed to Comdex Fall '89 in Las Vegas and concentrated on finding just the right one. While tramping up and down the aisles, I spotted the enclosure that I was looking for. Several computer manufacturers at the show were us-

EDN's PC All-Stars **THM91000AS-70 Memory Module**

Toshiba America Electonic Components Inc, 9775 Toledo Way, Irvine, CA 92718. (714) 455-2000. FAX (714) 859-3963.
Circle No. 668



STATS:
CAPACITY: 1M × 9 bits
SPECIAL ACCESS MODE: Fast page
RAS ACCESS TIME: 70 nsec
CAS ACCESS TIME: 20 nsec
CYCLE TIME: 130 nsec
FAST-PAGE-MODE CYCLE TIME: 40 nsec

BIO: The THM91000AS-70 is a SIMM (single in-line memory module) that holds 1M byte of data, plus a parity bit. Its fast-page access mode closely matches the burst access mode of the 80486 µP, which helps to optimize transfers between the processor and memory.

ing what was obviously the same enclosure; I even saw a gold-plated version. Most of these computers were file and network servers that incorporated several disk drives installed in the enclosure's drive cage. That cavernous cage had space for 10 half-height drives. But finding the right enclosure isn't the same as finding its vendor. The companies showing computers based on this enclosure either didn't know or wouldn't tell me who the vendor was.

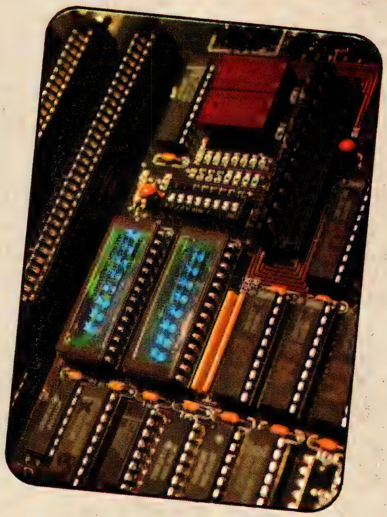
Finally, at one booth, I asked the wrong person: someone who worked for the enclosure vendor instead of the booth's owner. That's how I found Interface Electronics Inc. The All-Star PC uses the company's painted (not gold-plated) VES 1000 enclosure system. The enclosure has several outstanding features. In addition to the 10 drive bays, it has a removable card cage that is mounted vertically so that all of the PC's cabling exits from the top. If you've ever hooked a PC up to a few external peripherals such as printers, plotters, and displays, you know what a benefit it is to have the I/O connectors accessible from the top of the machine instead of the back, where most computer manufacturers put them. Once you've completed the connections, a steel cap slides over the cables making everything look neat and tidy.

The entire enclosure is made of steel, blocking those pesky EMI emissions that beckon the regulatory agencies. Hinged front and side doors provide easy access to the drive bays and the inside of the machine. Both doors lift off their hinges so that you can move them out of the way when assembling the system or during extended service

EDN's PC All-Stars

486 Modular BIOS

Award Software Inc, 130
Knowles Dr, Los Gatos, CA
95030. (408) 370-7979. FAX
(408) 370-3399. TWX 510-601-
0414.
Circle No. 669



STATS:
PROCESSOR SPEEDS HANDLED: 6-33 MHz, 0-2 wait states
MAXIMUM MEMORY SIZE MANAGED: 4G bytes
KEYBOARD COMPATIBILITY: 84, 101, and 102 keys
FLOPPY-DISK-DRIVE COMPATIBILITY: 5¼ and 3½ in.
HARD-DISK-DRIVE COMPATIBILITY: 40 drive types
CODE SIZE: 32k bytes

BIO: Derived from a long line of IBM-compatible BIOS ROMs, the 486 Modular BIOS supports the special features of the 80486 µP such as the on-chip cache and floating-point unit. Optional extensions include shadow RAM support and disk caching.

EDN's PC All-Stars

VES 1000 Enclosure System

Interface Electronics Inc, 2217
Claxter Rd NE, Salem, OR
97303. (503) 393-2838. FAX
(503) 393-1709.
Circle No. 670

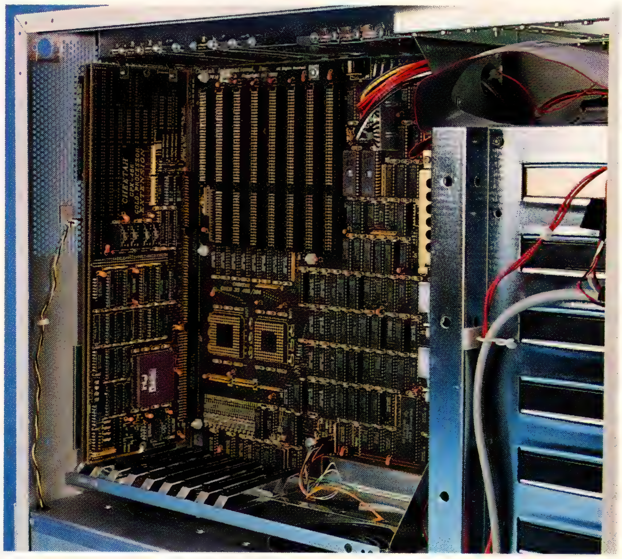
STATS:
SIZE: 24.5 × 9 × 23 in. (height, width, depth)
CARD-CAGE CAPACITY: 8-14 slots
DRIVE-BAY CAPACITY: 10 half-height drives
CABLE ACCESS: From the top
FRONT AND SIDE DOORS: Hinged and easily removable
UL recognized

BIO: Designed for high-end PCs such as file servers, the VES 1000 enclosure system can hold a large number of disk and tape drives and accommodates PC/AT-style and oversized mother boards. The steel construction helps reduce EMI emissions.

procedures. Even small features make the VES 1000 an attractive choice. For example, it uses the same-sized screw for all removable fasteners, so you don't need to keep track of different types of screws. The enclosure has many such well-thought-out features, including a slide-out air filter that keeps dust and dirt from entering the machine through the air inlet. Though perfect for the All-Star PC Project, the VES 1000 won't satisfy the requirements of every PC-based design, so Interface Electronics will customize the VES 1000 enclosure or develop new designs for other OEM requirements.

Only one problem remained. The VES 1000 doesn't accept AT-sized power supplies. Instead, it uses a 420W power supply that was custom designed and built by PC Power & Cooling. How's that for coincidence? I quickly exchanged the All-Star PC's Turbo 450 power supply for the company's ST450. The ST450 employs the Turbo 450's circuit board but has a larger housing so that it can accommodate two thermally controlled, variable-speed fans. The fans draw air through the power supply's enclosure and blow it over the VES 1000's card cage. This scheme provides significantly better cooling than the conventional PC/AT layout, a feature that high-end PCs like EDN's All-Star PC, which contain many high-power components, require. The ST450 thus matched the design of the VES 1000 and the requirements of this project perfectly. As I installed PC Power & Cooling's ST450 into the VES 1000, the last piece of the All-Star PC's foundation finally fell into place.

EDN



Resting snugly in the removable card cage, the Cheetah Gold 425 mother board and processor/memory daughter card await the expansion boards that will complete the foundation of the All-Star PC Project.

EDN's PC All-Stars

ST450 Custom Power Supply

PC Power & Cooling Inc, 31510 Mountain Way, Bonsall, CA 92003. (619) 723-9513. FAX (619) 723-0075.

Circle No. 671

STATS:

POWER OUTPUT: 420W (480W peak)

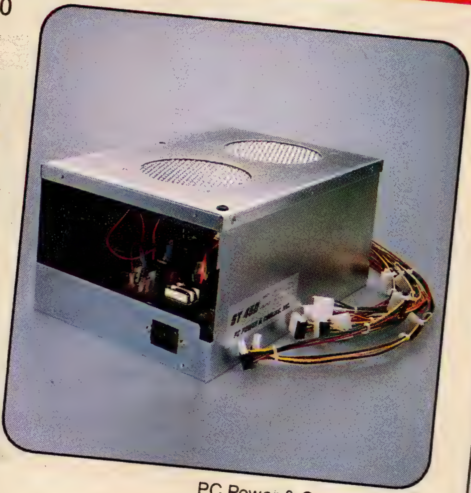
OUTPUTS: 5V@45A, 12V@15A (20A peak), −5V@0.5A, −12V@1A

OPERATING RANGE: 85-135V ac, 170-270V ac

PROTECTION: Spike, surge, brownout, overvoltage, overcurrent

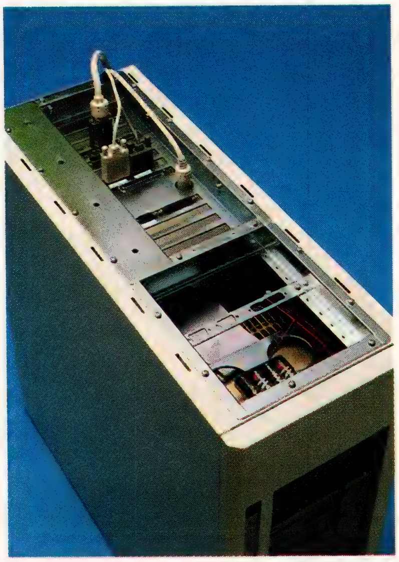
COOLING: Two temperature-controlled, variable-speed fans

MTBF: 50,000 hours



PC Power & Cooling Inc

BIO: The ST450 power supply operates from 110 and 220V mains and automatically chooses the proper input-voltage range. It has EMI filters on the ac inputs as well as independently regulated dc outputs with 3-stage output filters. The power supply meets UL, CSA, and TUV specs.



Putting the I/O cables at the top of the PC's enclosure simplifies making connections to external peripheral devices.

References

1. Nadeau, Michael E and Frank Hayes, "Psst! Wanna Buy an 80486 Cheap?," *Byte*, November 1989, pg 106.
2. Rinko-Gay, William L, "Cheetah and Olivetti 486s," *MIPS*, January 1990, pg 41.
3. Conner, Margery, "Low-cost workstations," *EDN*, November 9, 1989, pg 128.
4. Leibson, Steven H, "RISC design woos 32-bit μP architects," *EDN*, November 24, 1988, pg 122.
5. Markowitz, Michael C, "EDN's 16th Annual μP/μC Chip Directory," *EDN*, November 23, 1989, pg 92.

Acknowledgment

EDN gratefully acknowledges the loan of a Model 16500 logic analyzer and a B2403 Universal Interface for Intel's 80486 μP from Hewlett-Packard's Colorado Springs Div, which helped whip the All-Star PC's components into a team.

Article Interest Quotient
(Circle One)
High 512 Medium 513 Low 514

Looking for a job doesn't have to be one.

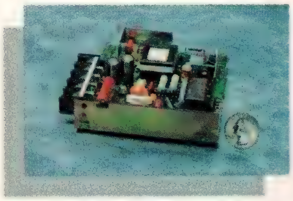
EDN's Career Opportunities section keeps you informed of current job openings from coast-to-coast

TURN TO PAGE 238

Sliced thin to fit.

Kepco's skinny switchers.

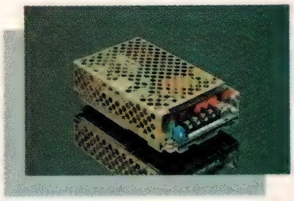
One inch, low profile solutions to the problem of inadequate space.



Series FAW

A group of single-output dc power supplies in 15, 25 and 50 Watt sizes. FAW feature a wide range (universal) input that accommodates 85-265V a-c. Built to the strict IEC 380/VDE 0806 standard, FAW have TÜV approval, as well as the imprimature of UL and CSA — FAW feature a built in FCC Class B/VDE 0871 level B EMI filter. L-chassis design with optional metal enclosure.

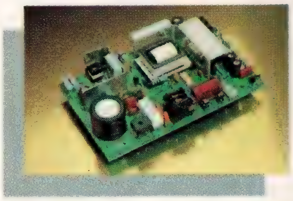
15W: *0.98 x 3.74 x 3.94 in.* ***25W:*** *0.98 x 3.74 x 4.92 in.* ***50W:*** *0.98 x 3.74 x 6.50 in.*



Series FAK

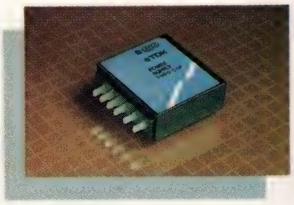
A group of miniature single-output dc power supplies in 15, 25 and 50 Watt sizes. FAK operate from North American mains power (85-132V a-c) and are built to the standards of UL 478/CSA 1402. FAK feature a built-in FCC Class B EMI filter. L-chassis design with optional metal enclosure.

15W: *0.79 x 2.76 x 3.74 in.* ***25W:*** *0.98 x 2.76 x 4.53 in.* ***50W:*** *0.98 x 3.74 x 5.12 in.*



Series MRW

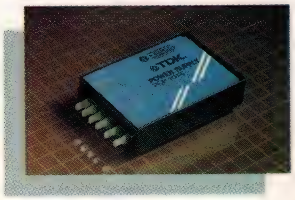
Triple output power supplies in the popular 100 X 160mm card size, MRW 150KV offer 35 Watts; MRW 160KV offer 50 Watts in the same footprint. Both feature a wide range (universal) input that accommodates 85-265V a-c. Built to the strict IEC 380/VDE 0806 standard, MRW have TÜV approval, as well as that of UL and CSA. MRW feature a built-in FCC Class B/VDE 0871 level B EMI filter. PC card design with optional metal enclosure. ***35W:*** *1.12 x 3.93 x 6.3 in.* ***50W:*** *1.5 x 3.93 x 6.3 in.*



Series FMP

Single output power supplies in 3W and 10W power sizes, FMP operate from North American mains power (85-132V a-c) and are built to the standards of UL 478/CSA 1402. FMP feature a built-in FCC Class B EMI filter. Fully enclosed design in a snap off plastic case.

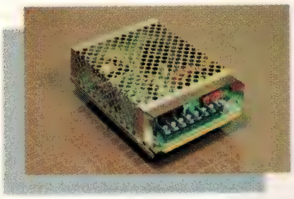
3W: *0.75 x 2.17 x 1.97 in.* ***10W:*** *0.75 x 2.17 x 3.15 in.*



Series FCP

Dual output power supplies (±12V and ±15V) in 3W and 10W power sizes. FCP operate from North American mains power (85-132V a-c) and are built to the standards of UL 478/CSA 1402. FCP feature a built-in FCC Class B EMI filter. Fully enclosed design in a snap off plastic case.

3W: *0.75 x 2.17 x 1.97 in.* ***10W:*** *0.75 x 2.17 x 3.15 in.*



Series ECM

Triple output power supplies. ECM operate from North American mains power (85-132V a-c) and are built to the standards of UL 478/CSA 1402. ECM feature a built-in FCC Class B EMI filter. Fully enclosed design in a metal enclosure.

16W: *1.28 x 3.60 x 4.72 in.*

SEE US AT ELECTRO/90 KEPCO BOOTH 3406, 3408

For your free copy of Kepco's new 56-page Switching Power Supply Catalog (#146-1692), call/fax/write to Dept. LNT-12, Kepco, Inc., 131-38 Sanford Ave., Flushing, NY 11352 USA
(718) 461-7000 • FAX (718) 767-1102 • Easylink (TWX): 710-582-2631

KEPCO®
THE POWER SUPPLIER™

CIRCLE NO. 123

Here's what we're up to.

Ontario, Canada, is a place of achievement. We pioneered telecommunications. Hydro electric power. Satellite transmission. Space robotics.

The result – a well-established infrastructure of skilled suppliers to the North American electronics industry. If you haven't explored this alternative source for quality components, it's time you took a look at what's here.

We give you quality, at a competitive price, without the inevitable problems caused by distance and language differences. We're your neighbours, and we think and talk like neighbours.

When you source in Ontario, it's as easy as dealing with a domestic supplier. You may find us easier to deal with. Ontario is close to major manufacturing centres of the U.S., and our excellent transportation links make us a prime partner for JIT and similar time-sensitive supply arrangements.

One phone call will bring you information about Ontario suppliers of the quality components you need.

Contact the International Electronics Marketing Consultant for the Government of Ontario, Canada at this number (416) 965-5436. Or write to the Ministry of Industry, Trade and Technology at 900 Bay Street, Hearst Block, Toronto, Ontario, Canada M7A 2E1.
Fax: (416) 965-7791.

Ontario, Canada: the best-kept secret of the North American electronics industry.

Ministry of Industry,
Trade and Technology
Ontario, Canada

CIRCLE NO. 11

Pulse-modulated divider suits multichannel systems

There are a handful of schemes for implementing analog division, and the traditional circuits perform quite well for many applications. However, a somewhat neglected circuit—the pulse-modulated divider—provides superior gain-matching characteristics for multichannel systems.

Dan Harres, *McDonnell Douglas Electronic Systems Co*

Many control applications require analog division. One example is the optical tracking required in both laser communications satellites and CD players. Traditional divider circuits include the transconductance-cell divider, the inverted multiplier, and the log-antilog divider. Each has advantages, but a pulse-modulated approach eases gain matching among channels for systems that require a common divisor.

Many traditional dividers employ a transconductance cell, which is also known as the Gilbert cell after its inventor, Barry Gilbert. A variable-transconductance multiplier or divider uses one of two input variables to control the gain of an active device. This device amplifies the other input in direct or inverse proportion to the control input (**Fig 1**). Direct amplification results in multiplication; inverse amplification results in division.

Like most linear approaches to division, the transconductance divider relies on the relationship between transistor base-to-emitter voltages and collector currents. This approach requires that you closely match resistor values and transistor characteristics. It also requires low op-amp input-offset currents. Since many monolithic op amps can satisfy these requirements, you can easily design a 2-quadrant transconductance-cell divider. You can apply both positive and negative values to the numerator input; the denominator input is typically unipolar. Such transconductance dividers can have dynamic ranges of 1000:1, constant bandwidths over an equally wide range, and 1% errors.

One problem with this circuit is not technical but logistical: Few monolithic versions of the entire transconductance cell are available. Burr-Brown (Tuscon, AZ) does make a transconductance-cell divider, the DIV100, which is suitable for designs other than military and space applications. As an alternative to dedicated ICs, you can implement a transconductance-cell divider with a quad op amp and matched transistor pairs. However, applications that need many such dividers (see **box,** "Optical tracking systems require precise division") require a large amount of circuitry. In addition, such tracking systems require that each channel has closely matched numerator-gain characteristics. Circuits with individual monolithic dividers do not lend themselves to precise matching.

One explanation for this lack of dedicated, monolithic dividers is that dividers are not common parts. Instead, manufacturers produce transconductance-cell multiplier ICs, which you can use to design inverted-multi-

A variable-transconductance multiplier or divider uses one input variable to control the gain of an active device.

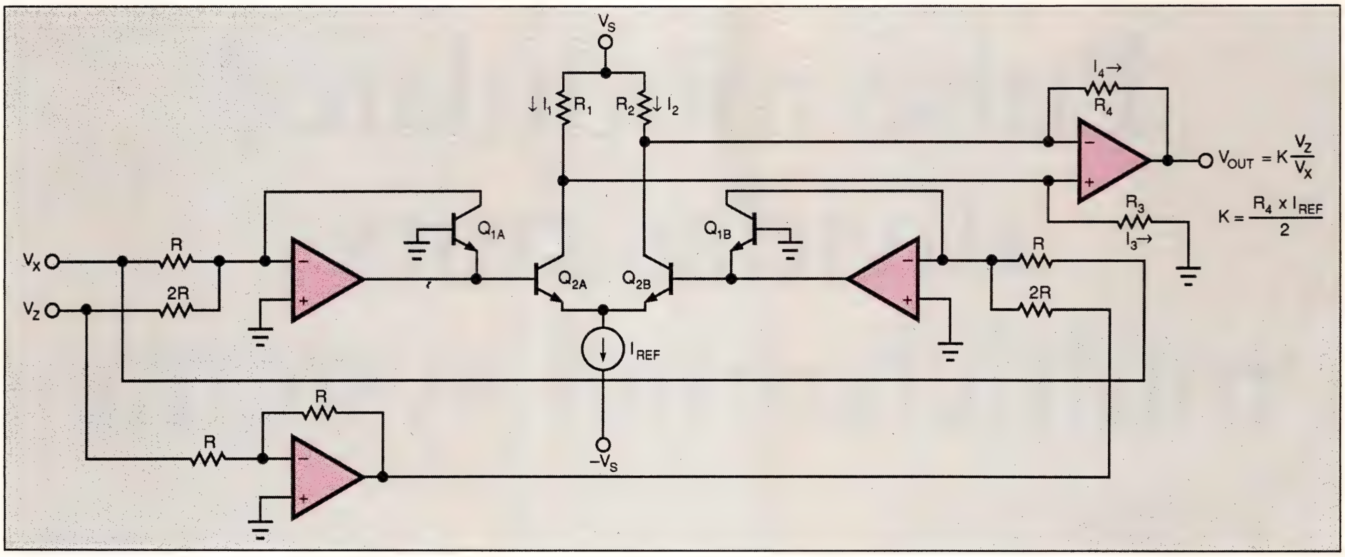


***Fig 1—The 2-quadrant transconductance-cell divider** typically features wide dynamic range and a constant bandwidth. If you're designing a multichannel system with a transconductance divider, you may have to closely match resistors, op amps, and currents. (Courtesy Analog Devices)*

plier dividers. If you put one of these chips in the feedback path of an op amp, you'll get its inverse function: division (**Fig 2**).

Most multiplier ICs include an op amp, thus making inverted-multiplier dividers simple to design. The biggest problem with this type of divider has to do with the input and output offset voltages of the multiplier. The second term in **Fig 2**'s equation reveals that the divider's offset error depends on the value of the denominator voltage: Error increases as the denominator voltage decreases. Other potential problems with using multiplier ICs are bandwidth and phase that vary with the denominator voltage; gain changes due to drift in the multiplier scale factor; instabilities due to the interaction of multiplier and op-amp poles; and multiplier nonlinearities. The offset errors are a particular problem in satellite design because the effects of the Van Allen radiation belts and other cosmic radiation can wreak havoc with the dc accuracy of active circuits. Offsets of devices subjected to such radiation can increase by more than an order of magnitude.

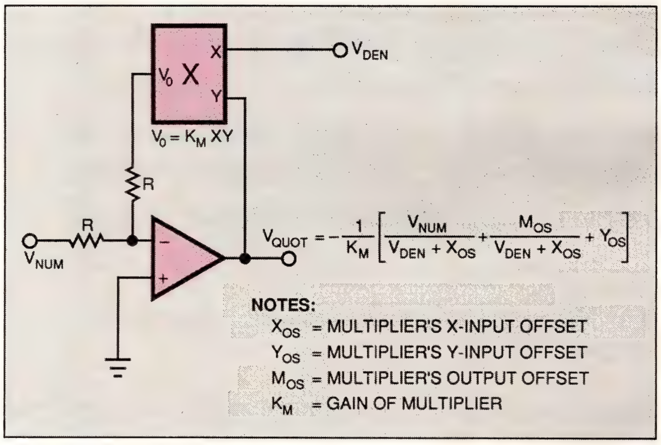

V_0 X
X
Y
V_{DEN}
$V_0 = K_M XY$
R
R
V_{NUM}
$V_{QUOT} = -\frac{1}{K_M}\left[\frac{V_{NUM}}{V_{DEN} + X_{OS}} + \frac{M_{OS}}{V_{DEN} + X_{OS}} + Y_{OS}\right]$
NOTES:
X_{OS} = MULTIPLIER'S X-INPUT OFFSET
Y_{OS} = MULTIPLIER'S Y-INPUT OFFSET
M_{OS} = MULTIPLIER'S OUTPUT OFFSET
K_M = GAIN OF MULTIPLIER

***Fig 2—By inserting a multiplier into an op amp's feedback path,** you can implement the inverted-multiplier divider.*

Subtract logs to divide

Another common approach to analog division dates back to the days of analog computers. These computers often used a log-antilog function to implement multiply and divide functions. Taking the logarithms of the numerator and denominator voltages and then taking the antilogarithm of their difference produces the quotient of the two voltages. Although the log-antilog divider has considerable computational ability, it has one serious limitation for laser communications: It is a single-quadrant device. Logarithms and devices based on logarithmic action have defined behavior only for positive values. Most dividers can handle a bipolar numerator voltage, but the log-antilog divider cannot. Circuit designs that boost bipolar voltage can get around this problem, but such designs add circuit complexity and tend to degrade the log-antilog divider's dc performance.

Another disadvantage of transconductance-cell and log-antilog dividers is that they can't achieve the channel matching required for multichannel, common-denominator operation. The pulse-modulated divider avoids these limitations.

You can, theoretically, make the numerator offset of the pulse-modulated divider equal to zero. This zero offset is important in control applications where the numerator offset contributes to a nulling error. In addition, systems that divide several analog channels by a common denominator require that those channels have matching gains. That is, the absolute gain of a particular channel may not matter as long as all channels have the same gain. The pulse-width part of the pulse-modulated circuit constitutes the bulk of the divider and contributes the bulk of the errors. Since this part of the circuit is common to all channels of a multichannel system, pulse-modulated dividers provide excellent gain matching between channels.

Optical tracking systems require precise division

Laser communications satellites and CD players both require optical tracking systems (**Fig A**) to keep a laser beam pointed at a particular point. Any offset from the center of the quadrature device produces an error voltage in the axis in which the offset occurred. This error creates an actuator drive voltage, which moves the laser beam back to the null position. By forming the sum and difference equations, optical tracking systems create a null error voltage for the X and Y axes.

To ensure loop stability and proper loop response time, the loop gain must remain fairly constant. However, the loop gain depends on the laser's output power, the detector's conversion efficiency, and, in satellite applications, the distance between communicating satellites. These parameters can vary. Thus, the system needs to normalize the error voltage generated by the detector.

The system normalizes these error signals by dividing the X_N and Y_N error signals from the quadrant detector by the sum of the error signals from all four quadrants. This procedure makes proper loop operation possible.

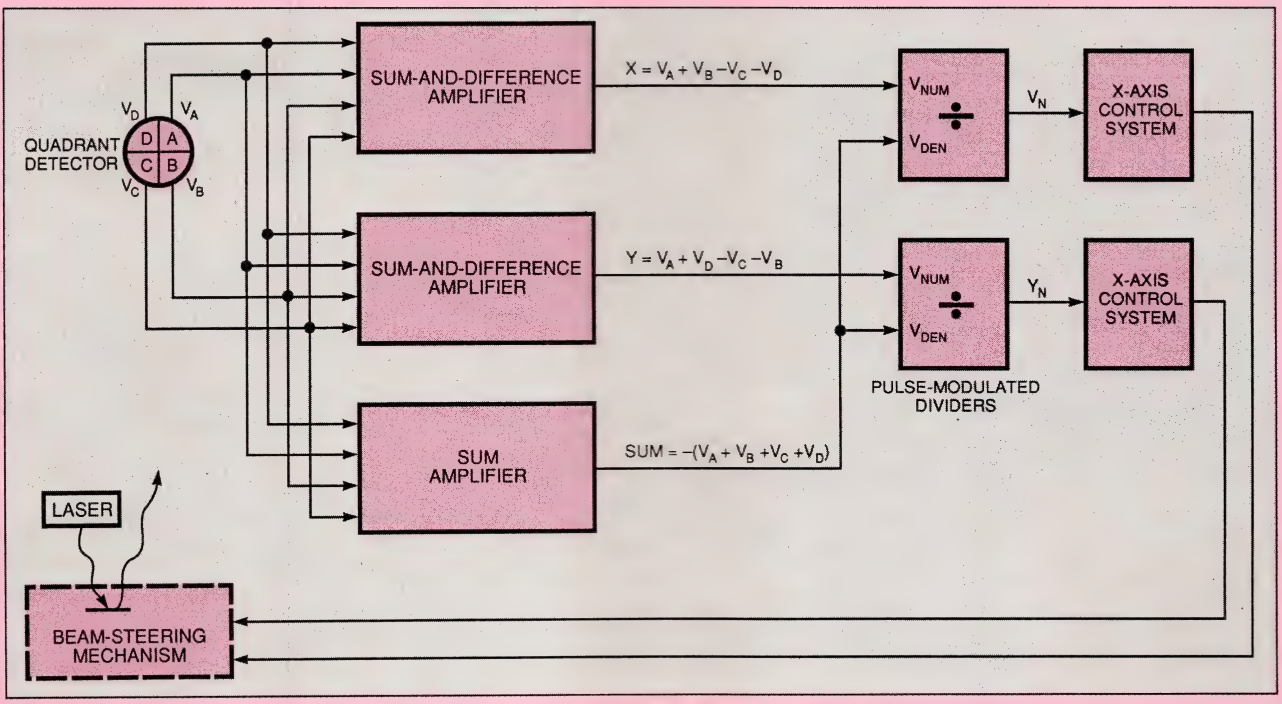


__Fig A—Precise analog dividers__ normalize the quadrant-detector errors, X and Y, of this optical tracking system.

Circuits with individual monolithic dividers do not lend themselves to precise matching.

The pulse-modulated divider is a variation of the pulse-modulated multiplier **(Fig 3a)**. The multiplier's integrator and comparator produce a pulse, at V_{SWITCH}, whose width, Δt, is directly proportional to the input voltage, V_X. This pulse controls a switch that alternately passes and inhibits the passage of a second voltage, V_Y. The result, V_{OUT}, is a pulse train whose peak value is V_Y and whose average value is

$$V_{AVG}=\frac{\Delta t}{T}V_Y=K\ V_XV_Y.$$

A reset-pulse train of frequency T determines the intervals at which the circuit produces these pulses. Although the average value of this pulse train at V_{OUT} is the correct product, the signal obviously contains useless high-frequency energy. You can remove the high-frequency signals by low-pass filtering the output at the expense of the circuit's bandwidth.

With only slight modifications, this circuit will divide instead of multiply. Notice that the block diagram of the divider in **Fig 3c** differs from the multiplier in only one way: **Fig 3c**'s circuit swaps the reference voltage with one of the pulse-modulated input voltages. The divider's integrator does not slew at a constant rate to reach some variable voltage, as does the multiplier's integrator. Instead, it slews at a variable rate determined by the divider's denominator voltage to reach a constant reference limit. This change creates a pulse whose width is inversely proportional to the denominator voltage. As with the multiplier, this pulse controls the switch action. The output of the divider circuit's switch is a pulse train whose peak amplitude is the numerator voltage and whose average value is proportional to the ratio of the numerator and denominator voltages, V_{NUM} and V_{DEN}.

The circuit in **Fig 4a** is one implementation of the pulse-modulated divider. The integrator and compara-

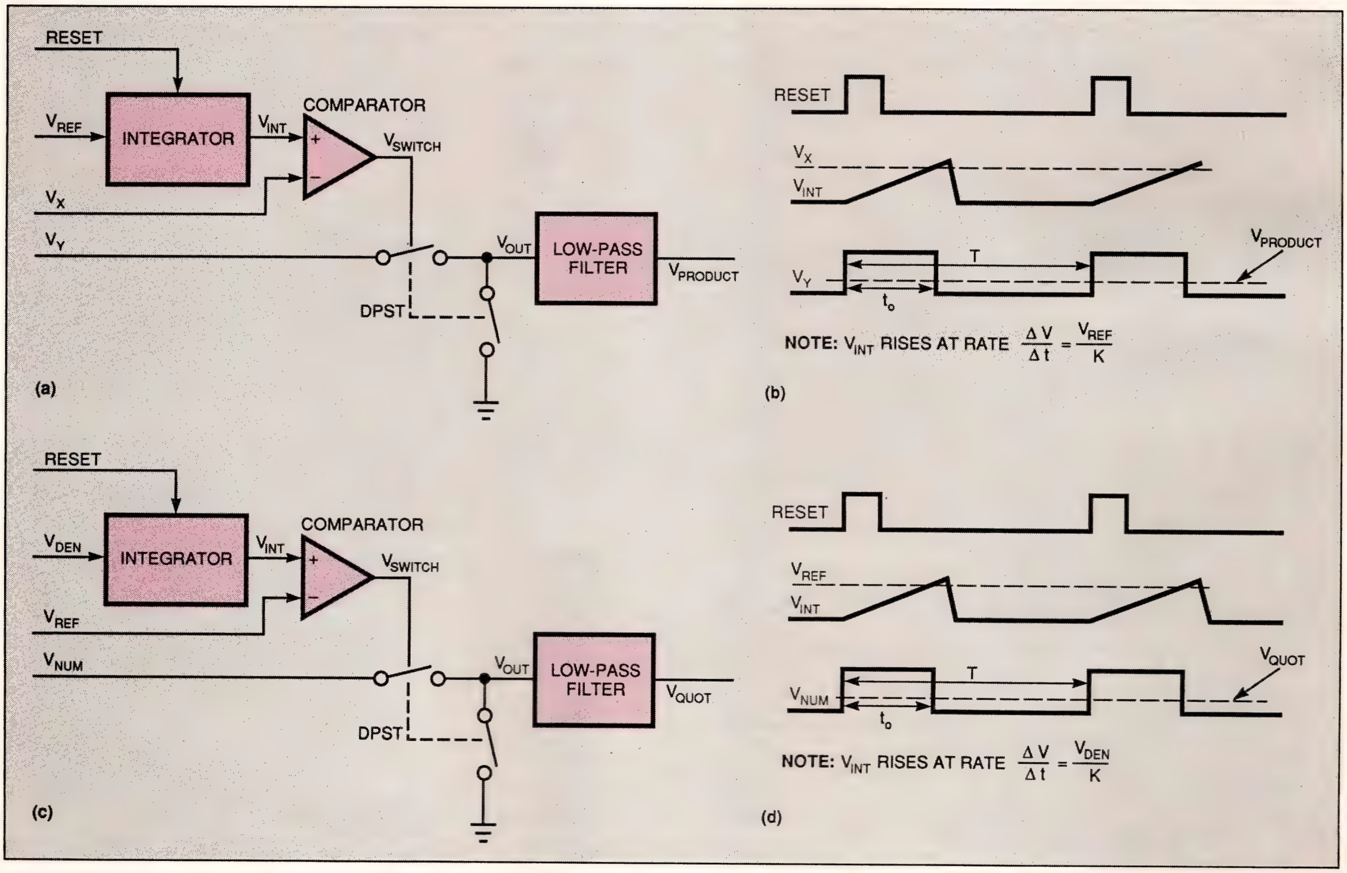


***Fig 3—The pulse-modulated divider (c)** differs from the multiplier version **(a)** only in the input locations of the reference voltage and pulse-modulated voltage. The corresponding timing diagrams in **b** and **d** show that the multiplier and divider operations differ only in that the multiplier integrator rises at a constant rate and the divider integrator rises at a variable rate determined by the denominator voltage.*

tor drive SW_2 and SW_3 to produce pulses whose widths are inversely proportional to the denominator voltage. The reset pulse's leading edge causes the integrator output to begin slewing at a rate proportional to $-V_{DEN}$. The higher the amplitude of V_{DEN}, the faster the integrator reaches the comparator's switching voltage and, therefore, the narrower the output pulse. The integrator output, V_{INT}, rises according to the equation

$$V_{INT}=\frac{\Delta t\ V_{DEN}}{R_1C_1}.$$

Solving for Δt yields

$$\Delta t=\frac{R_1C_1V_{INT}}{V_{DEN}}.$$

When the integrator reaches the switching voltage, $V_{REF}1+(R_2/R_3)$, the pulse has the following width:

$$\Delta t=t_0=\frac{R_1C_1V_{REF}(1+R_2/R_3)}{V_{DEN}}.$$

R_2 and R_3 produce positive feedback, which maintains the comparator output at its high level, even after the integrator's output returns to zero. The comparator output goes low only after the reset pulse occurs. Repeating the entire process every T seconds produces the following average value for the output's voltage quotient, V_{QUOT}:

$$V_{QUOT}=\frac{t_0}{T}V_{NUM}=\frac{R_1C_1(1+R_2/R_3)}{T}\ \frac{V_{NUM}}{V_{DEN}}=K\frac{V_{NUM}}{V_{DEN}}.$$

Although the pulse-modulated divider has certain advantages, you should recognize where it deviates from ideal performance. The effects of aliasing, output ripple, offset voltages, offset currents, passive-component tolerances, and timing uncertainties can all degrade the divider's performance. You can take steps to minimize these effects.

First of all, SW_2 and SW_3 essentially sample the numerator voltage. Thus, the pulse-modulated divider is a type of sampled-data system, and you'll need to consider the effects of aliasing. The sample rate of the divider, T, is generally an order of magnitude or more above the highest frequency of the numerator signal, so you might not think that aliasing would be a problem. However, noise may exist well beyond the sample rate. In noise-limited applications, the high-frequency noise may alias down and add to the lower-frequency noise to create a problem. For this reason, **Fig 4a** includes the simple RC filter comprising R_6 and C_2 to filter any high-frequency noise.

Another potential problem is output ripple. The pulse-modulated divider does a good job of producing an accurate average value; however, as its name implies, the output is a pulse train and contains lots of high-frequency energy. In other words, ripple exists in the raw output. The low-pass filter comprising R_7 and C_3 removes the ac component of the output, leaving only the average value. In addition, when such a divider controls an actuator or other electromechanical device, the control loop's natural break frequency and the device's lack of response at high frequencies attenuate the ripple significantly.

Changes in the component values, the sampling interval T, or V_{REF} will result in a corresponding change in the pulse width, t_O, and, therefore, the gain of the divider. Because offset voltages in the comparator will cause shifts in the reference voltage, they will also affect the denominator's gain. Most control applications are tolerant of changes in gain of 20% or more. Thus, common components with moderately good dc characteristics and a simple astable multivibrator to produce T will suffice. For applications in which the gain is critical, you'll need to use more accurate components and crystal oscillators.

Because pulse-width modulation controls the denominator voltage, timing errors will generate denominator offsets. When reset occurs, the comparator must change state, SW_1 must turn off, the op amp must begin to slew, SW_3 must turn off, and SW_2 must turn on. When the integrator reaches threshold, the comparator must change state, SW_2 must turn off, and SW_3 must turn on. Any difference in the timing delay between these two sets of events will create a denominator offset.

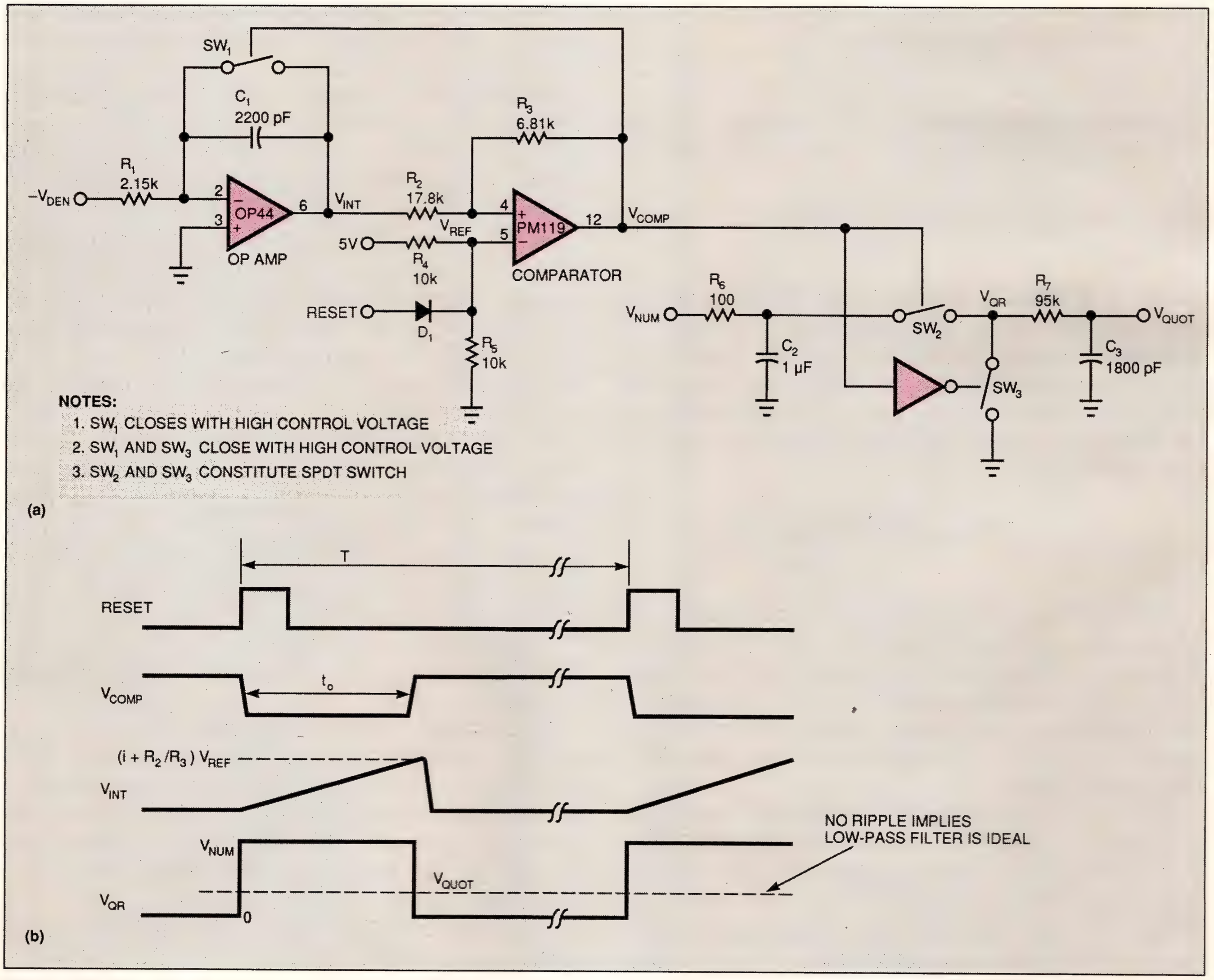
As an example of how timing errors affect denominator offset, consider a divider with a 50-μsec max pulse width, a 10:1 dynamic range, and a 100-nsec mismatch between pulse turn-on and turn-off times. Because the dynamic range is 10:1, the minimum pulse width corresponding to the maximum denominator voltage is 5 μsec. The 100-nsec timing error out of a total of 5 μsec is equivalent to a 200-mV offset error for a 10V denominator voltage.

A more critical source of error in most control loops is the numerator offset. The pulse-modulated divider

A pulse-modulated divider works well in control applications for which gain matching is more important than speed and ripple characteristics.

is free of the offset voltages and currents that plague traditional dividers. However, charge coupling from the SW_2 and SW_3 drivers through their internal capacitances to their common switch node, V_{QR}, is a new source of offset. If the turn-on and turn-off voltage spikes produced by charge-coupling are equal in magnitude but opposite in sign, no net offset occurs. Offset does occur when the spikes at each edge are not equal. This coupling is similar to a capacitive divider, but the situation is more complex. The amount of offset due to charge coupling varies both from one manufacturer's switch IC to the next and between CMOS and JFET switches, so you'll probably want to experiment with a variety of switches (**Ref** 3). Also, by increasing T you can increase the period of time over which the circuit averages the spike energy, thereby decreasing the spike-generated dc offset.

You can't buy a single-IC pulse-modulated divider, but you can build the circuit in **Fig** 4 with standard parts. SW_1 can be part of the switch IC that includes S_2 and S_3, or it can be a discrete switch, such as a VMOS power FET. The op amp must have a slew rate that can accommodate the maximum integrator slew rate, and the comparator must have a switching time fast enough to satisfy the denominator's offset requirements. Using an OP44 op amp and a PM119 comparator, **Fig 4a**'s circuit features a 50-µsec repetition period, a denominator offset of 15 mV, a numerator offset



NOTES:
1. SW_1 CLOSES WITH HIGH CONTROL VOLTAGE
2. SW_1 AND SW_3 CLOSE WITH HIGH CONTROL VOLTAGE
3. SW_2 AND SW_3 CONSTITUTE SPDT SWITCH

Fig 4—With the values shown, *this pulse-modulated divider* ***(a)*** *has a 50-µsec repetition period and a 10-mV p-p output ripple.*

Annie Oakley/The Bettman Archive Inc.

One of the precise hand-held instruments that didn't need one of our cable assemblies.

Annie never missed. Well, almost never. As long as she was ahead of second best, the room for error was there.

Not so in the critical engineering of micro-miniature cable and connector solutions at Precision Interconnect. Tolerances are getting tighter, desired sizes smaller, and development time shorter.

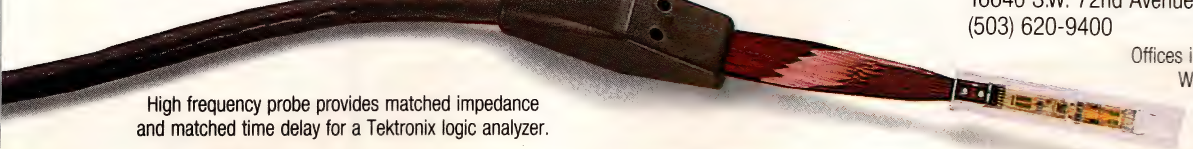
Working with exact electrical requirements, plus challenging mechanical parameters, we design and produce extremely reliable, long flex-life cable, with conductors terminated to standard connectors or active devices, and with protective flex-strain reliefs. These complete interconnect systems, usually using 30 AWG and smaller conductors, provide the critical link in hand-held applications on test and measurement equipment and medical diagnostic devices.

Our expertise, increasing with each unique problem we solve, ensures that reliability is designed in, built in, and tested. So we're right on target. Every time.

PRECISION INTERCONNECT

16640 S.W. 72nd Avenue, Portland, OR 97224
(503) 620-9400

Offices in San Francisco, Boston, Wilmington and Düsseldorf



High frequency probe provides matched impedance and matched time delay for a Tektronix logic analyzer.

CIRCLE NO. 92

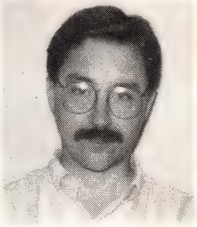
of 1.5 mV, and output ripple at V_{QUOT} of 10 mV p-p. This circuit works well in control applications for which gain matching is more important than speed and ripple characteristics. **EDN**

References

1. *Nonlinear Circuits Handbook*, Analog Devices Inc, 1976.
2. "Dynamic Input Characteristics of VMOS Power Switch," Application Note AN79-3, Siliconix Inc, 1979.
3. "CMOS Analog Multiplexers and Switches; Applications Considerations," Application Note 520, Harris Corp.

Author's biography

Dan Harres designs communications and control electronics for laser satellites at McDonnell Douglas, where he has worked for 11 years. He holds a BS in computer engineering from the University of Illinois and an MS in electrical engineering from the University of Missouri at Rolla. In his spare time, Dan enjoys bicycling with his wife and son.



Article Interest Quotient (Circle One)
High 491 Medium 492 Low 493

WHAT'S COMING IN EDN

EDN Magazine's March 29, 1990, issue will feature a staff-written Special Report on C compilers and debuggers. Part 2 of EDN's All-Star PC project will focus on mass-storage options for PCs. And we will introduce a 2-part technology feature with a discussion of optimizing code for parallel processors. Remember to look for our regular departments, too.

CMS SINCE 1947

Manufacturing

CMS has the manufacturing flexibility to meet your low or high volume production requirements for quality custom Molded-On® cable assemblies. CMS order processing is designed to deliver 100% on time shipments. Our 40 years of experience help you meet the challenges of today's dock to stock and JIT requirements. Call or write Component Manufacturing Service, Inc.; One Component Park, West Bridgewater, MA 02379. Tel. (508) 580-0111.

CMS is the Molded-On® connector company.

CIRCLE NO. 8

1,239,580 Filters

Lowest prices in America on small quantities

0.1 Hz to 500 MHz

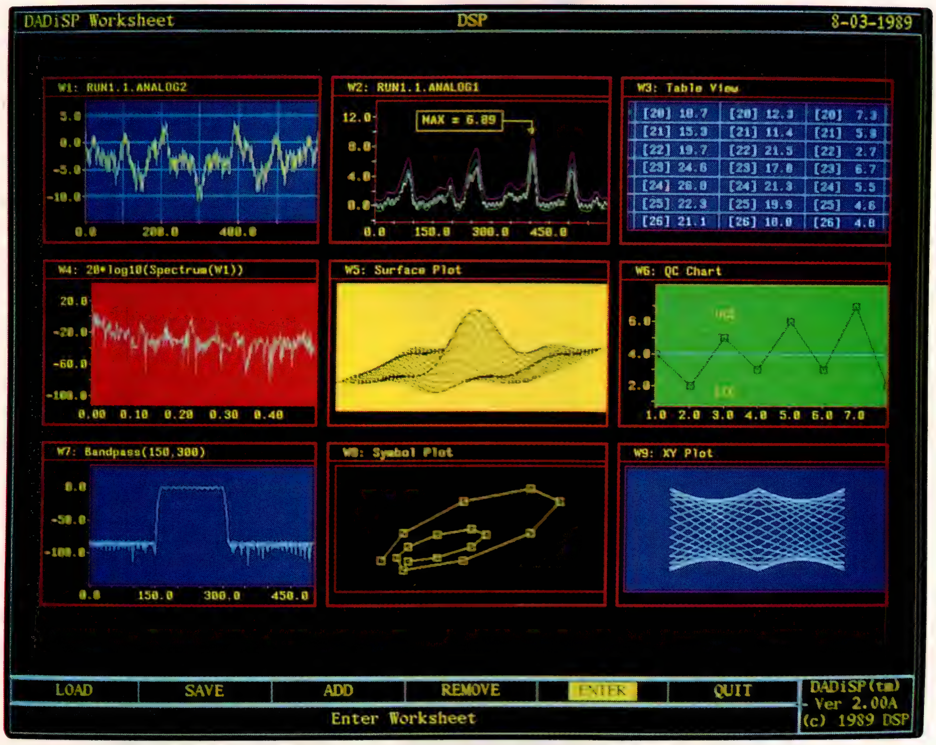
1,239,580 standard filter types ☐ Miniature and subminiature sizes ☐ Passive and active types ☐ Telemetry filters ☐ Gaussian, Butterworth, Chebyshev designs ☐ Call or write for free catalog today.

TTE

TTE, Inc.
11652 W. Olympic Blvd.
Los Angeles, CA 90064
(213) 478-8224

CIRCLE NO. 9

Introducing DADiSP 2.0



[20] 10.7	[20] 12.3	[20] 7.3
[21] 15.3	[21] 11.4	[21] 5.8
[22] 19.7	[22] 21.5	[22] 2.7
[23] 24.6	[23] 17.0	[23] 6.7
[24] 26.0	[24] 21.3	[24] 5.5
[25] 22.3	[25] 19.9	[25] 4.6
[26] 21.1	[26] 10.0	[26] 4.0

DADiSP. The Big Picture in Signal Processing

DADiSP — interactive graphics and data analysis software for scientists and engineers. DADiSP 2.0 delivers unprecedented power, through easy-to-use menus. Choose from hundreds of analysis functions and graphic views — from tables to 3-D. Simultaneously display multiple windows, each with different data or analyses, for unlimited perspective on your toughest data analysis problems.

Build your own analysis worksheets — build and display an entire signal processing chain, *without programming*. And DADiSP's powerful graphic spreadsheet automatically recalculates and updates the entire chain if you change your data or a processing step.

Do serious signal processing...the way you always pictured it! FFTs, digital filter design, convolutions, waterfall plots, and more — all at the press of a key.

Let your instruments do the talking — use DADiSP-488 to bring data from your instruments directly into a DADiSP window for immediate viewing and analysis.

Flexible, expandable, customizable — annotate your graphs and send them to printers, plotters, or publishing packages. Create your own macros, automate routine tasks, and run any program written in any language from within DADiSP. *DADiSP even lets you build your own menus.*

A proven standard — already used by thousands of engineers and scientists worldwide, in a whole range of applications like medical research, chemistry, vibration analysis, communications, manufacturing quality control, test & measurement, and more. DADiSP supports the IBM PC and PS/2, SUN, DEC VAX, HP 9000 and Concurrent families of personal computers and workstations.

GET THE PICTURE!
CALL TODAY 617-577-1133

Ask for our Evaluation Disk. For more information, write to DSP Development Corporation, One Kendall Square, Cambridge, MA 02139, or FAX: 617-577-8211.

DSP
Development
Corporation

Australia-Interworld Electronics, 03 521-2952; England-Adept Scientific, (0462) 683355; Biosoft, (0223) 68622; Finland-Turion, 0-372-144; France-SM2I, (1) 34810178; Sacasa, 69077802; West Germany-Datalog, (02166) 46082; Stemmer Electronik, 089-809 02-0; Israel-Racom Electronics, 03-491-922; Italy-BPS Computers, (02) 61290221; Japan-Astrodesign, 044-751-1011; Netherlands-Computer Engineering Roosendaal, 01650-57417; New Zealand-GTS Engineering, (09) 392 464; Sweden-Systek, 013 110140; Switzerland-Urech & Harr AG, 61 611325; Taiwan-Advantech, 2-351-2117

CIRCLE NO. 93

NEED BROAD-BAND COAXIAL RELAYS?
FROM 2 TO 24 THROW, MATRIX HAS THE ANSWER

Our versatile 7000 series of coaxial relays have band-widths from DC up to 800 MHz. They're available from 2 to 24 throw. And by using our 9000 series cross-straps, switching matrices of any size can be configured.

Why have Matrix broad-band relays become the industry standard? Because we construct them of precision machined anodized aluminum alloy, all signal shield paths are silver plated, and basic switch elements are hermetically sealed in nitrogen filled gas envelopes with rhodium plated contacts to insure non-stick operation.

The end result is extremely low crosstalk, EMI and VSWR. Another plus, all switchpoints are individually field replaceable.

The units are plug compatible with Matrix 6100A and 1600 Series Logic Modules for compatibility with RS-232, RS-422 and IEEE-488 Interface busses as well as 16 bit parallel.

Non-blocking Matrix configuration may be easily assembled using our self-terminating relays and 5100A series power dividers. Built-in Video/RF amplifiers allow zero insertion loss designs.

So if you're looking for broadband relays, it pays to deal with Matrix. After all, we've been designing state-of-the-art reed relay and semiconductor switching systems for over 18 years.

Our customers include government agencies, defense contractors, the TV industry, ATE and telecommunications companies—and more.

For free catalog, phone, write, FAX or TWX Matrix today.

MATRIX
SYSTEMS CORPORATION

5177 NORTH DOUGLAS FIR ROAD
CALABASAS, CALIFORNIA 91302
(818) 992-6776 · TWX 910-494-4975

See us at Electro, Booth #1736
CIRCLE NO. 94

Cache memories and MMUs work together in high-speed systems

When you use cache-memory systems with today's high-speed RISC and CISC CPUs, you must often coordinate them with sophisticated memory-management units.

Raymond M Leong, *Cypress Semiconductor*

Placing a static-RAM (SRAM) cache-memory system between a CPU and the main memory lets you use slow, low-cost dynamic RAMs (DRAMs) in the larger main memory. The overall system maintains the speed performance of the fast SRAMs. This technique's success is based on the probability that the data the CPU needs is in the fast SRAMs. The principle at work is the locality principle, which states that the data currently in use will be needed again shortly (temporal locality) and the execution of data from the main memory is generally sequential (spatial locality).

A cache-memory system has three parts: a cache-data SRAM, which contains data that the CPU expects to use shortly; a cache-tag SRAM, which maps the CPU's address into pointers for locating data in the cache-data SRAM; and the cache controller, which coordinates the CPU's memory accesses to the cache memory and the main memory. **Fig 1** shows a typical cache-memory-system block diagram.

You have to take a variety of factors into account to design an effective cache-memory system. In every basic cache-memory system, you must choose a cache-memory size, a line size, a method for associating the cache-tag RAM with the cache-data RAM, and a policy for ensuring data consistency in the main and cache memories. (See **box,** "Basic cache considerations," for an explanation of how cache memories work and definitions of cache-memory terms.) Once you've made these choices, some options can significantly shorten the inherent time delays of a cache-memory system.

For example, by having a wide data path between the cache memory and the main memory, you can significantly shorten the time required to transfer a line. Some high-speed computers employ data paths that are 64 or 128 bits wide. In addition, using DRAMs that support burst transfers in the main memory can reduce the overhead involved when transferring multiple words. Popular burst-mode DRAM architectures include nibble mode, which handles as many as four words for each access, and static-column mode, which requires only column accesses for data residing in the same DRAM row.

In addition, write-buffer and read-buffer memories in the cache controller can enhance the performance of both the write-through and copy-back cache policies. In the write-through policy, the controller may generate CPU wait states when writing data into the main memory. A write-buffer memory eliminates these wait states by capturing the data so that a controller can

By using a wide data path between the cache memory and the main memory, you can significantly shorten the time needed to transfer a line.

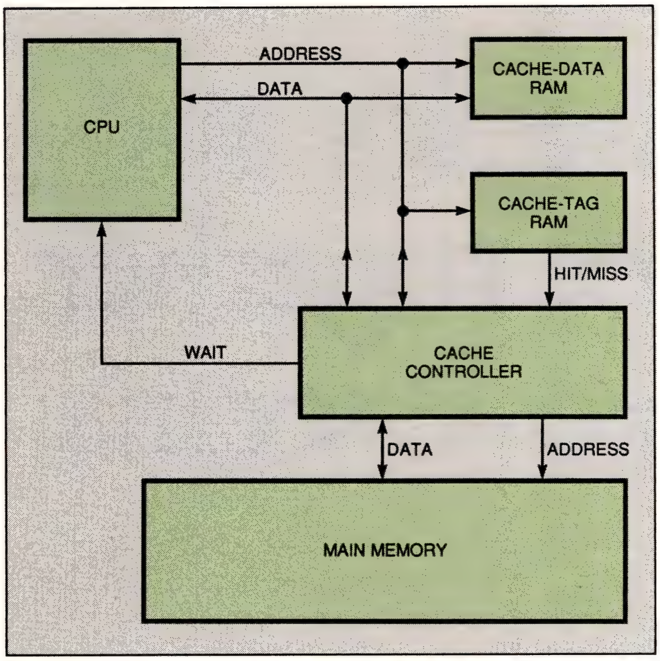


Fig 1—A cache-memory system consists of three components: *a cache-data RAM for storing data, a cache-tag RAM to identify the data, and a cache controller to coordinate data transfers between the main memory and the cache system.*

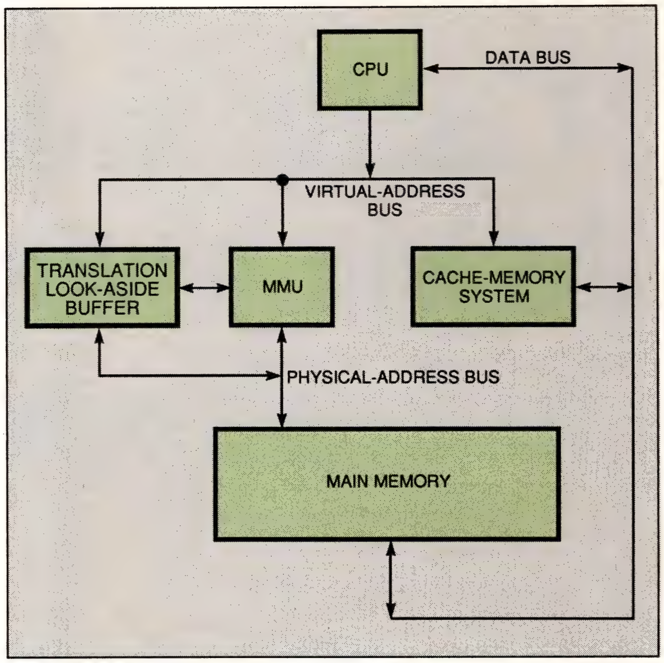


Fig 2—A virtual-cache memory operates *with the virtual addresses from the CPU. The cache controller must coordinate with the MMU and TLB when transferring data between the main memory and the cache memory.*

release the CPU. In the copy-back policy, the controller must transfer a modified line back to the main memory. A read-buffer memory provides temporary storage for the retrieved modified line. The controller writes the modified line in the read buffer into the main memory at a later time.

Caches with multiple contexts

Technology advances have created a new set of considerations when configuring a cache-memory system. A few years ago, only 16k-byte cache RAMs were feasible, but advances in large-density SRAM technology have made 64k-byte cache RAMs commonplace today. Consequently, a cache memory containing data associated with more than one context, or software task, is a practical reality.

Whenever a software program switches context—such as during a subroutine call, a task switch in multitasking operation, or an operating-system call—the controller must flush some old data in the cache memory to make room for data for the new context. If the controller flushes all of the data in the cache, many cache misses will occur before the cache refills. You can reduce the number of misses by assigning an additional address field, called a context field, to each cache-tag address. Because a context field identifies each line as unique, the controller can flush individual lines.

Today's high-speed cache-memory systems often operate in conjunction with a memory-management unit (MMU). Modern 32-bit RISC (reduced-instruction-set computer) and CISC (complex-instruction-set computer) processors use an MMU, which translates a virtual address from the CPU into a physical address in main memory. Because these 32-bit µPs are capable of addressing 4G bytes, the physical-address space of the main memory is generally smaller than the virtual-memory range. The MMU effectively provides a large contiguous programming area by mapping virtual addresses to available physical main-memory locations using page tables maintained by the operating system. Page sizes usually range from 512 to 8k bytes.

Because walking through page tables is time consuming, MMUs employ an additional cache RAM, called a translation look-aside buffer (TLB). The TLB contains a physical-address map for the most recently used virtual addresses. When the CPU generates a virtual address, the MMU searches the TLB for a matching physical address. A hit in the TLB results in a fast translation time; a miss requires the MMU to place the

Basic cache considerations

Designing a cache-memory system requires that you make some basic decisions. One such decision is cache-memory size. To reap the benefit of the cache's fast access time, a system should have a high percentage of cache-memory hits when the CPU issues a memory-access call. Obviously, a large cache memory has a greater hit probability than a small cache memory, but the faster devices in the larger cache memory are quite expensive.

You'll also have to choose a cache-memory architecture for associating the set of addresses in the cache-tag RAM with the set of data in the cache-data RAM. The most popular architectures are fully associative, direct-mapped, 2-way set associative, and 4-way set associative **(Ref 1)**. **Fig Ab** shows the effect of different architectures on the cache-miss rates of different cache sizes. The curves show that associativity has a negligible effect on the miss rate for cache sizes greater than 64k bytes.

The principle of locality states that the CPU will probably request data located in the immediate vicinity of previously requested data in the near future. Therefore, controllers generally transfer a block of data into the cache-data RAM when a cache miss occurs. The amount of data transferred into the RAM is called a line and affects the cache-miss rate **(Fig Aa)**. The time required for the controller to transfer a line determines the time delay incurred before the system bus becomes available. A long time delay can affect the system's overall performance.

In addition, you must select a cache policy for ensuring data consistency between the cache memory and the main memory. Two popular policies are the write-through and the copy-back methods. When using the write-through policy, the controller updates the main memory immediately after a cache-write access modifies the cache-data RAM. Because the write-through policy guarantees consistent data in both memory systems at all times, it is frequently used where data protection is crucial. However, the write-through policy suffers a drawback: The controller must issue a main-memory access even when a hit occurs in the cache as a result of a cache-write command.

When using the copy-back policy, the controller updates the main memory only when the controller replaces a modified line in the cache-data RAM. The controller sets a bit in the cache-tag RAM for each modified line to distinguish the line from an unmodified line. Because the copy-back policy doesn't require a main-memory access on a cache-write command, it has a higher hit rate than the write-through policy.

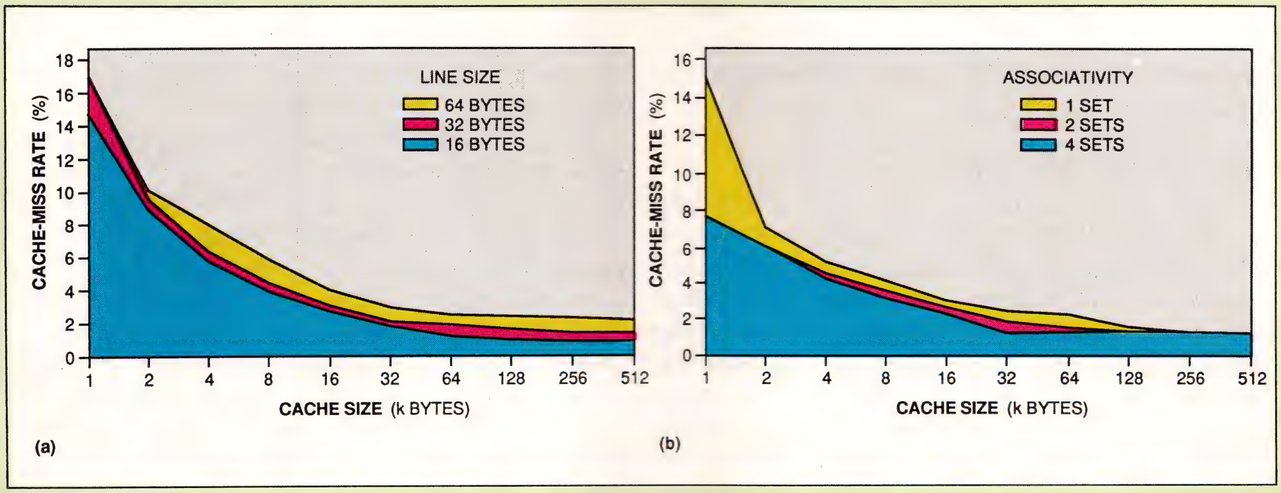


Fig A—The amount of data transferred in one line (a) *and the cache's associativity* ***(b)*** *affect the number of hits and misses in the cache. The effect depends on the size of the cache. (Fig courtesy* ACM Transaction on Computers ***(Ref 1))***

Because the MMU performs address translations, a virtual-cache-memory system is subject to address aliasing.

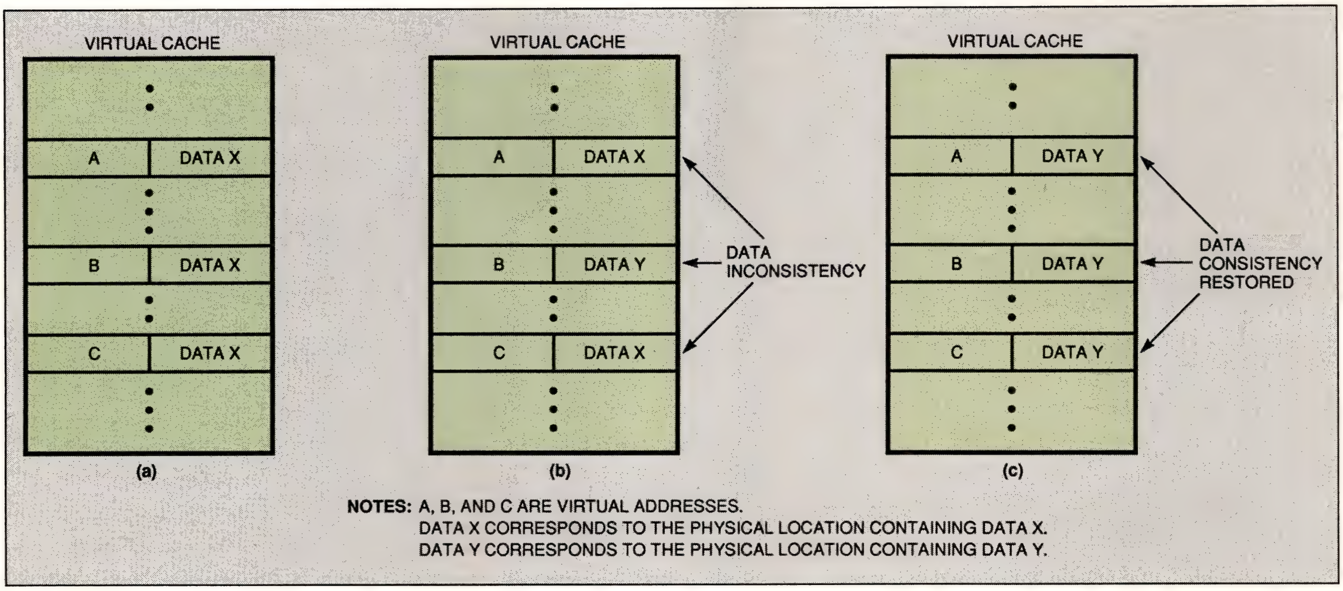

VIRTUAL CACHE
A
DATA X
B
DATA X
C
DATA X
(a)
VIRTUAL CACHE
A
DATA X
B
DATA Y
C
DATA X
DATA INCONSISTENCY
(b)
VIRTUAL CACHE
A
DATA Y
B
DATA Y
C
DATA Y
DATA CONSISTENCY RESTORED
(c)
NOTES: A, B, AND C ARE VIRTUAL ADDRESSES.
DATA X CORRESPONDS TO THE PHYSICAL LOCATION CONTAINING DATA X.
DATA Y CORRESPONDS TO THE PHYSICAL LOCATION CONTAINING DATA Y.

***Fig 3—Address aliasing occurs in a virtual-cache-memory system** when more than one virtual address maps into one physical address **(a)**. When the CPU modifies only one of the virtual addresses, it creates a data inconsistency **(b)**. Therefore, the virtual cache requires a method for restoring consistency **(c)**.*

CPU on hold and leaf through page tables to obtain the physical address.

High-speed caches in virtual-memory systems must coordinate with the MMU. You could design the cache-memory system using the physical addresses from the MMU, but the translation time delay for many high-speed systems can be prohibitive—even if a hit occurs in the TLB. For example, RISC systems can generate a memory-access call on each clock interval. This rate is faster than the MMU can search the TLB. Therefore, high-speed systems employ a cache system, called a virtual cache, which uses the virtual address from the CPU (**Fig 2**).

Virtual caches create aliases

In a virtual-cache memory, the MMU comes into play only when there is a cache miss. However, a virtual-cache memory has a unique complication: address aliasing. This problem occurs when the operating system maps a single physical location into two or more virtual addresses. **Fig 3** illustrates address aliasing. In this example, virtual addresses A, B, and C translate to the same physical address containing datum X. A data inconsistency results when the CPU or the cache controller updates the data in one of the shared locations without modifying the data in the remaining shared locations.

You can prevent address aliasing by prohibiting the storage of data from one physical location into more than one location in the virtual cache. However, this approach limits the system's flexibility. Another approach—albeit time consuming—is updating all virtual-cache locations mapped to the same physical address whenever the CPU modifies one of the virtual-cache locations via a write. To implement this approach, you must employ logic circuitry to compare the physical address for each cache-tag entry with the physical address corresponding to the virtual write address. If the physical addresses match, the circuitry must modify the data in the cache-data RAM that correspond to the matching virtual address.

You can reduce the aliasing-checking time by imposing a software restriction that requires all virtual addresses mapped to the same physical location to reside within the same cache line. When a cache line is replaced during a cache miss, the cache controller compares the physical-address translation of the evicted line with the physical-address translation of the CPU-generated virtual address. A match means the evicted cache line and the new cache line correspond to the same physical locations. The controller doesn't have to access the main memory because the old cache line and its intended replacement contain the same data. In other words, detecting the alias condition creates an effective cache hit. The cache controller simply updates the cache-tag entry to reflect the new mapping.

We Believe The World Is Flat...

or soon will be.

The world is turning to flat panel displays. And Yamaha LSI is there — with the only complete line of single-chip and board-level graphic controllers in the industry. We're the controlling force behind most of the world's portable computer displays. So, if there's a flat panel display in your future, there are many good reasons to turn to Yamaha LSI.

Whether you need CGA, EGA or VGA, our advanced controllers support all leading flat panel display technologies, plus CRTs. They can even control the newest color displays.

Our patented techniques automatically convert color software to gray scale on LCDs and to hatching patterns on EL and plasma displays. Our newest controllers correct aspect ratio problems, so circles look like circles instead of ovals.

Our single-chip solutions are ideal for all new designs, especially laptops and portable devices. With four chips to choose from, you can have the distinct level of control and resolution you need.

Our Display Master® family of auto-initializing IBM compatible board-level controllers is ideal if you need a ready-made solution. These boards are compatible with EL, Plasma, LCD and CRT technologies and support nearly all manufacturers' displays.

Single-Chip	
VGA, EGA, CGA, MDA	V6388
EGA, CGA, MDA	V6377
CGA, MDA, Hercules	V6366
CGA, MDA	V6355
Board-Level	
Display Master VGA	YDM6448
Display Master EGA	YDM6435
Display Master	YDM6420

(Optional integrated -24V power supply for LCDs)

And, they're available in a wide range of resolutions. Just plug the card into your PC, set DIP switches and go. No additional hardware or software modification is needed.

We've been building this family of controllers for over six years.

Call 1-800-543-7457. Do it today. We'll make you a flat world believer too!

YAMAHA® LSI

Systems Technology Division
981 Ridder Park Drive
San Jose, CA 95131
(408) 437-3133 FAX (408) 437-8791

CIRCLE NO. 95

The ability to lock specific entries in the TLB ensures a fast address translation time for time-critical memory-resident codes such as trap handlers.

MMUs have a variety of enhancements that can help you design an effective cache-memory system. The Cypress CY7C604 CMU (cache controller and memory-management unit) integrates a cache controller, a cache tag, a 32-byte read buffer, a 32-byte write buffer, an MMU, and a TLB in a single IC. Both this CMU and Fujitsu's MB86920 MMU have TLBs that translate addresses for multiple contexts. The CMU also has a context register, which stores the context number of the current software task. When the MMU searches the cache tag or TLB, it declares a match only when the address and the context bits match. This feature lets you retain useful tag and TLB entries instead of having the CMU flush the entire cache and TLB.

Another enhancement is an MMU's ability to lock specific entries in the TLB, which ensures a fast address translation time for time-critical memory-resident codes such as trap handlers. Some MMUs, such as Motorola's MC68851, let you lock as many as 63 of its 64 TLB entries. This MMU employs a lock bit stored in both the TLB and the page tables. The operating system sets the lock bit in frequently used TLB entries so that fast address translation is guaranteed for those pages. The CMU eliminates the lock bit by implementing the locking mechanism via a 6-bit programmable counter. You can load any number between 0 and 63 into the counter. You can replace all TLB entries between the loaded counter value and 63 when the rest of the TLBs are locked.

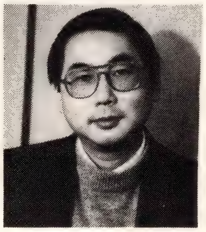
When a miss occurs in the TLB, an MMU spends a lot of time searching through page tables in the main memory to find a physical address that matches the current virtual address. MMUs employ a tree-type search, in which they narrow in on a page using either two or three levels of branching. In a 3-level search, the MMU must access three levels of page tables before locating the requested page. Once the MMU locates the page, it copies the physical location in the TLB. The MMU also writes a bit to the page tables to remind the operating system that a copy of the translation resides in the TLB. Essentially, the 3-level-tree search requires three main-memory read accesses and one main-memory write access.

Because the CPU generally issues sequential addresses to the TLB, the probability of accessing adjacent pages is high. The MMU stores a pointer to the third-level page table of the last tree search. Thus, the number of accesses needed to retrieve the physical translation for adjacent pages during subsequent TLB misses is only one read and one write—a saving of two read-access cycles. **EDN**

Reference

1. Agarwal, A, J Hennesy, and M Horwitz, "Cache Performance of Operating Systems and Multiprogramming Workloads," *ACM Transaction on Computers*, Vol 6, No. 4, November 1988.

Author's biography



Raymond M Leong is a senior staff engineer in the Product Planning and Applications Dept of Cypress Semiconductor Corp, where he has worked for two years. He is responsible for the product definition of memory components and specializes in the development of cache controllers, memory-management units, RAMs, PROMs, and programmable logic devices. He holds an MSCS from the University of California at Berkeley.

Article Interest Quotient (Circle One)
High 494 Medium 495 Low 496

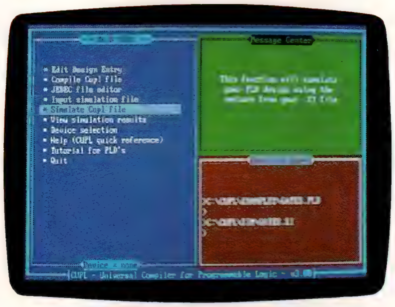
WHAT'S COMING IN EDN

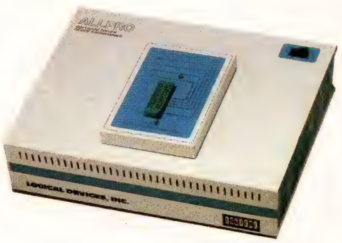
EDN Magazine's March 29, 1990, issue will feature a staff-written Special Report on C compilers and debuggers for real-time software. Part 2 of EDN's All-Star PC project will focus on mass-storage options for PCs. And we will introduce a 2-part technology feature with a discussion of optimizing code for parallel processors. Remember to look for our regular departments, too.

EDN's April issues will cover FAX/modem ICs and DSP add-in boards for IBM PCs.

Making a PROM Burner is Easy...

Making a Flexible and Reliable Device Programmer is Something Else.





GANGPRO-S™ ...an industrial grade GANG/SET programmer for high-volume production.

- 32-32 pin or 16-40 pin EE/EPROM capacity.
- Reliable quad redundant design minimizes downtime.
- Virtual algorithm code and space memory architecture assure upgradeability.
- Extensive error checking operations.
- Minimal operator skill required.

CUPL™ ...the first high level, universal language for PLDs.

- Schematic entry, state machine or boolean equation design formats.
- Comprehensive data base support library.
- Compatible with MS-DOS, UNIX and VMS.
- 24 hour/7day dial up bulletin board for update information.
- Worldwide field support.

ALLPRO™ ...the universal device programming workstation that grows with your needs.

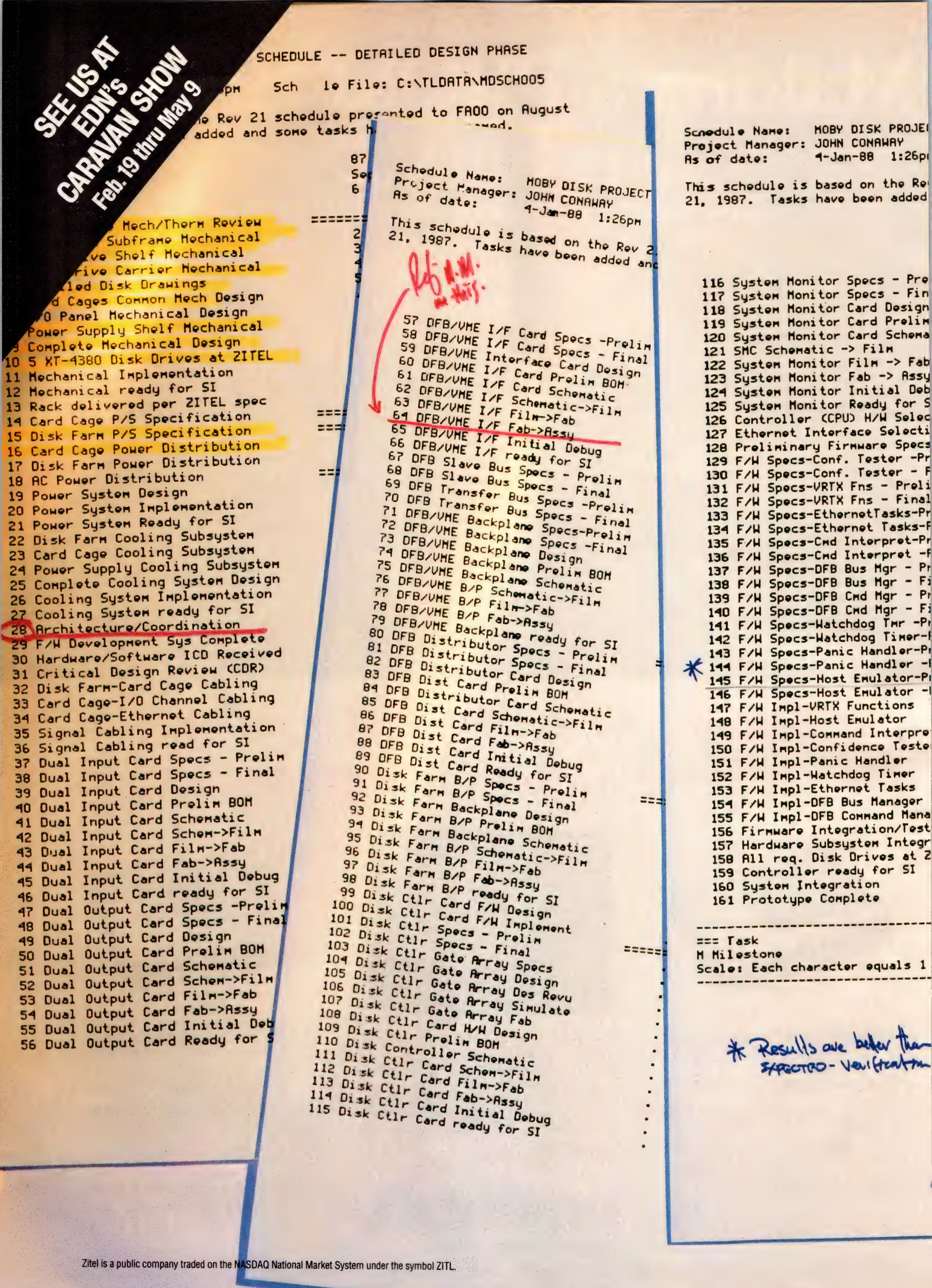
- Programs over 1800 device types (PLDs, PROMs, Micros).
- Continous device support program by floppies.
- No adapters or plug-in electronics.
- Totally pin/software driven.
- Certified by major PLD manufacturers.
- High performance, menu-driven or macro-driven user interface software.

LOGICAL
DEVICES, INC.

1201 NW 65th Place. Fort Lauderdale, Florida 33309. FAX 305/974-8531 Toll Free 800-EE1-PROM. Telex 383142

CIRCLE NO. 124

©1988 Logical Devices, Inc.


SEE US AT
EDN's
CARAVAN SHOW
Feb. 19 thru May 9

```
SCHEDULE -- DETAILED DESIGN PHASE

   pm    Sch   le File: C:\TLDATA\MDSCH005

  e Rev 21 schedule presented to FA00 on August
    added and some tasks h

                                              87
                                              Se
                                              6

    Mech/Therm Review                     =======
    Subframe Mechanical                       2
   ve Shelf Mechanical                        3
   rive Carrier Mechanical                    4
   lled Disk Drawings                         5
   d Cages Common Mech Design
   0 Panel Mechanical Design
  Power Supply Shelf Mechanical
  9 Complete Mechanical Design
10 5 XT-4380 Disk Drives at ZITEL
11 Mechanical Implementation
12 Mechanical ready for SI
13 Rack delivered per ZITEL spec
14 Card Cage P/S Specification
15 Disk Farm P/S Specification
16 Card Cage Power Distribution
17 Disk Farm Power Distribution
18 AC Power Distribution
19 Power System Design
20 Power System Implementation
21 Power System Ready for SI
22 Disk Farm Cooling Subsystem
23 Card Cage Cooling Subsystem
24 Power Supply Cooling Subsystem
25 Complete Cooling System Design
26 Cooling System Implementation
27 Cooling System ready for SI
28 Architecture/Coordination
29 F/W Development Sys Complete
30 Hardware/Software ICD Received
31 Critical Design Review (CDR)
32 Disk Farm-Card Cage Cabling
33 Card Cage-I/O Channel Cabling
34 Card Cage-Ethernet Cabling
35 Signal Cabling Implementation
36 Signal Cabling read for SI
37 Dual Input Card Specs - Prelim
38 Dual Input Card Specs - Final
39 Dual Input Card Design
40 Dual Input Card Prelim BOM
41 Dual Input Card Schematic
42 Dual Input Card Schem->Film
43 Dual Input Card Film->Fab
44 Dual Input Card Fab->Assy
45 Dual Input Card Initial Debug
46 Dual Input Card ready for SI
47 Dual Output Card Specs -Prelim
48 Dual Output Card Specs - Final
49 Dual Output Card Design
50 Dual Output Card Prelim BOM
51 Dual Output Card Schematic
52 Dual Output Card Schem->Film
53 Dual Output Card Film->Fab
54 Dual Output Card Fab->Assy
55 Dual Output Card Initial Deb
56 Dual Output Card Ready for S
```

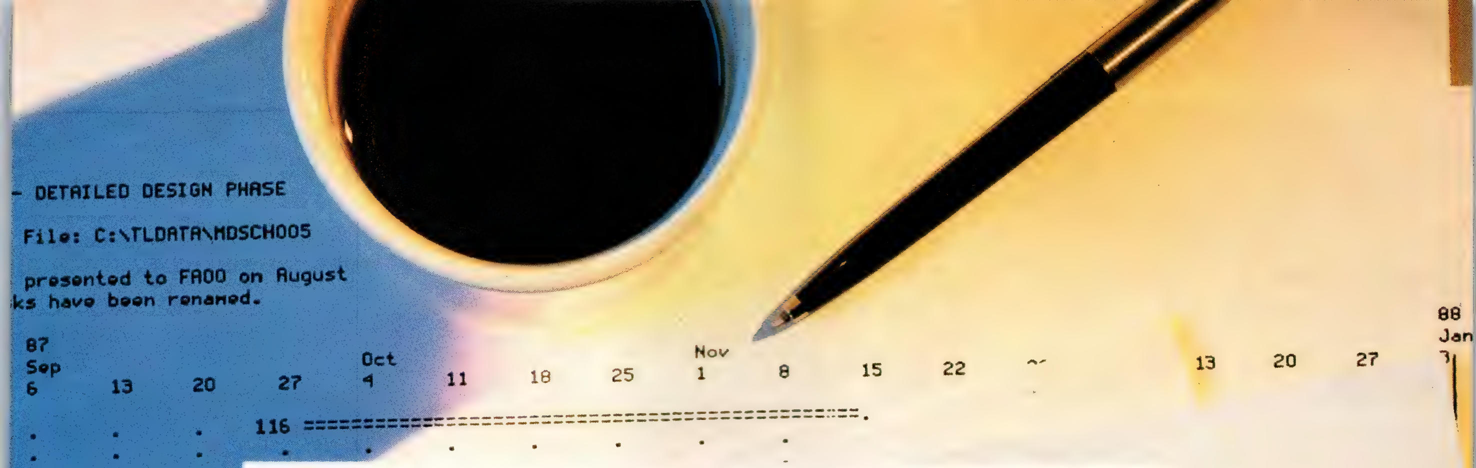
```
Schedule Name:    MOBY DISK PROJECT
Project Manager:  JOHN CONAWAY
As of date:       4-Jan-88   1:26pm

This schedule is based on the Rev 2
21, 1987.  Tasks have been added an

 57 DFB/VME I/F Card Specs -Prelim
 58 DFB/VME I/F Card Specs - Final
 59 DFB/VME Interface Card Design
 60 DFB/VME I/F Card Prelim BOM
 61 DFB/VME I/F Card Schematic
 62 DFB/VME I/F Schematic->Film
 63 DFB/VME I/F Film->Fab
 64 DFB/VME I/F Fab->Assy
 65 DFB/VME I/F Initial Debug
 66 DFB/VME I/F ready for SI
 67 DFB Slave Bus Specs - Prelim
 68 DFB Slave Bus Specs - Final
 69 DFB Transfer Bus Specs -Prelim
 70 DFB Transfer Bus Specs - Final
 71 DFB/VME Backplane Specs-Prelim
 72 DFB/VME Backplane Specs -Final
 73 DFB/VME Backplane Design
 74 DFB/VME Backplane Prelim BOM
 75 DFB/VME Backplane Schematic
 76 DFB/VME B/P Schematic->Film
 77 DFB/VME B/P Film->Fab
 78 DFB/VME B/P Fab->Assy
 79 DFB/VME Backplane ready for SI
 80 DFB Distributor Specs - Prelim
 81 DFB Distributor Specs - Final
 82 DFB Distributor Card Design
 83 DFB Dist Card Prelim BOM
 84 DFB Distributor Card Schematic
 85 DFB Dist Card Schematic->Film
 86 DFB Dist Card Film->Fab
 87 DFB Dist Card Fab->Assy
 88 DFB Dist Card Initial Debug
 89 DFB Dist Card Ready for SI
 90 Disk Farm B/P Specs - Prelim
 91 Disk Farm B/P Specs - Final
 92 Disk Farm Backplane Design
 93 Disk Farm B/P Prelim BOM
 94 Disk Farm Backplane Schematic
 95 Disk Farm B/P Schematic->Film
 96 Disk Farm B/P Film->Fab
 97 Disk Farm B/P Fab->Assy
 98 Disk Farm B/P ready for SI
 99 Disk Ctlr Card F/W Design
100 Disk Ctlr Card F/W Implement
101 Disk Ctlr Specs - Prelim
102 Disk Ctlr Specs - Final
103 Disk Ctlr Gate Array Specs
104 Disk Ctlr Gate Array Design
105 Disk Ctlr Gate Array Des Revu
106 Disk Ctlr Gate Array Simulate
107 Disk Ctlr Gate Array Fab
108 Disk Ctlr Card H/W Design
109 Disk Ctlr Prelim BOM
110 Disk Controller Schematic
111 Disk Ctlr Card Schem->Film
112 Disk Ctlr Card Film->Fab
113 Disk Ctlr Card Fab->Assy
114 Disk Ctlr Card Initial Debug
115 Disk Ctlr Card ready for SI
```

Ref. M.M. on this.

```
Schedule Name:    MOBY DISK PROJE
Project Manager:  JOHN CONAWAY
As of date:       4-Jan-88   1:26p

This schedule is based on the Re
21, 1987.  Tasks have been added

116 System Monitor Specs - Pre
117 System Monitor Specs - Fin
118 System Monitor Card Design
119 System Monitor Card Prelim
120 System Monitor Card Schema
121 SMC Schematic -> Film
122 System Monitor Film -> Fab
123 System Monitor Fab -> Assy
124 System Monitor Initial Deb
125 System Monitor Ready for S
126 Controller (CPU) H/W Selec
127 Ethernet Interface Selecti
128 Preliminary Firmware Specs
129 F/W Specs-Conf. Tester -Pr
130 F/W Specs-Conf. Tester - F
131 F/W Specs-VRTX Fns - Preli
132 F/W Specs-VRTX Fns - Final
133 F/W Specs-EthernetTasks-Pr
134 F/W Specs-Ethernet Tasks-F
135 F/W Specs-Cmd Interpret-Pr
136 F/W Specs-Cmd Interpret -F
137 F/W Specs-DFB Bus Mgr - Pr
138 F/W Specs-DFB Bus Mgr - Fi
139 F/W Specs-DFB Cmd Mgr - Pr
140 F/W Specs-DFB Cmd Mgr - Fi
141 F/W Specs-Watchdog Tmr -Pr
142 F/W Specs-Watchdog Timer-
143 F/W Specs-Panic Handler-Pr
144 F/W Specs-Panic Handler -
145 F/W Specs-Host Emulator-Pr
146 F/W Specs-Host Emulator -
147 F/W Impl-VRTX Functions
148 F/W Impl-Host Emulator
149 F/W Impl-Command Interpre
150 F/W Impl-Confidence Teste
151 F/W Impl-Panic Handler
152 F/W Impl-Watchdog Timer
153 F/W Impl-Ethernet Tasks
154 F/W Impl-DFB Bus Manager
155 F/W Impl-DFB Command Mana
156 Firmware Integration/Test
157 Hardware Subsystem Integr
158 All req. Disk Drives at Z
159 Controller ready for SI
160 System Integration
161 Prototype Complete

------------------------------
=== Task
M Milestone
Scale: Each character equals 1
------------------------------
```

* Results are better than expected - verification

Zitel is a public company traded on the NASDAQ National Market System under the symbol ZITL.



161 REASONS TO LET ZITEL SIGN ON FOR YOUR NEXT PROJECT.

So you've got to design, build and bring to market a high performance memory product for your company. And you need it yesterday.

Now there's an easy solution: Call Zitel.

We've been designing and building fast, reliable memory solutions for defense, medical and satellite imaging, flight and radar simulation and geoseismic exploration for over 10 years. Our team will provide you with the solution you need. On time and on budget.

A case in point: Moby Disk, shown in this ad. It took 161 steps to take this 20 Gigabyte, 24 I/O channel 30 MByte/second 40 disk array from customer specification to first item delivery.

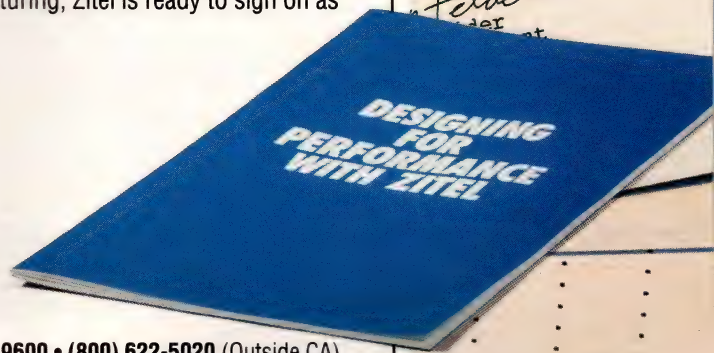
Moby Disk was delivered and installed in 13 months – 5 months ahead of schedule. And it was right the first time.

Call 1-800-622-5020 for complete information on the Zitel Task Management program and a free booklet, "Designing for Performance with Zitel." From custom design, to system integration, to high quality manufacturing, Zitel is ready to sign on as your partner.

zitel

Memories of the future

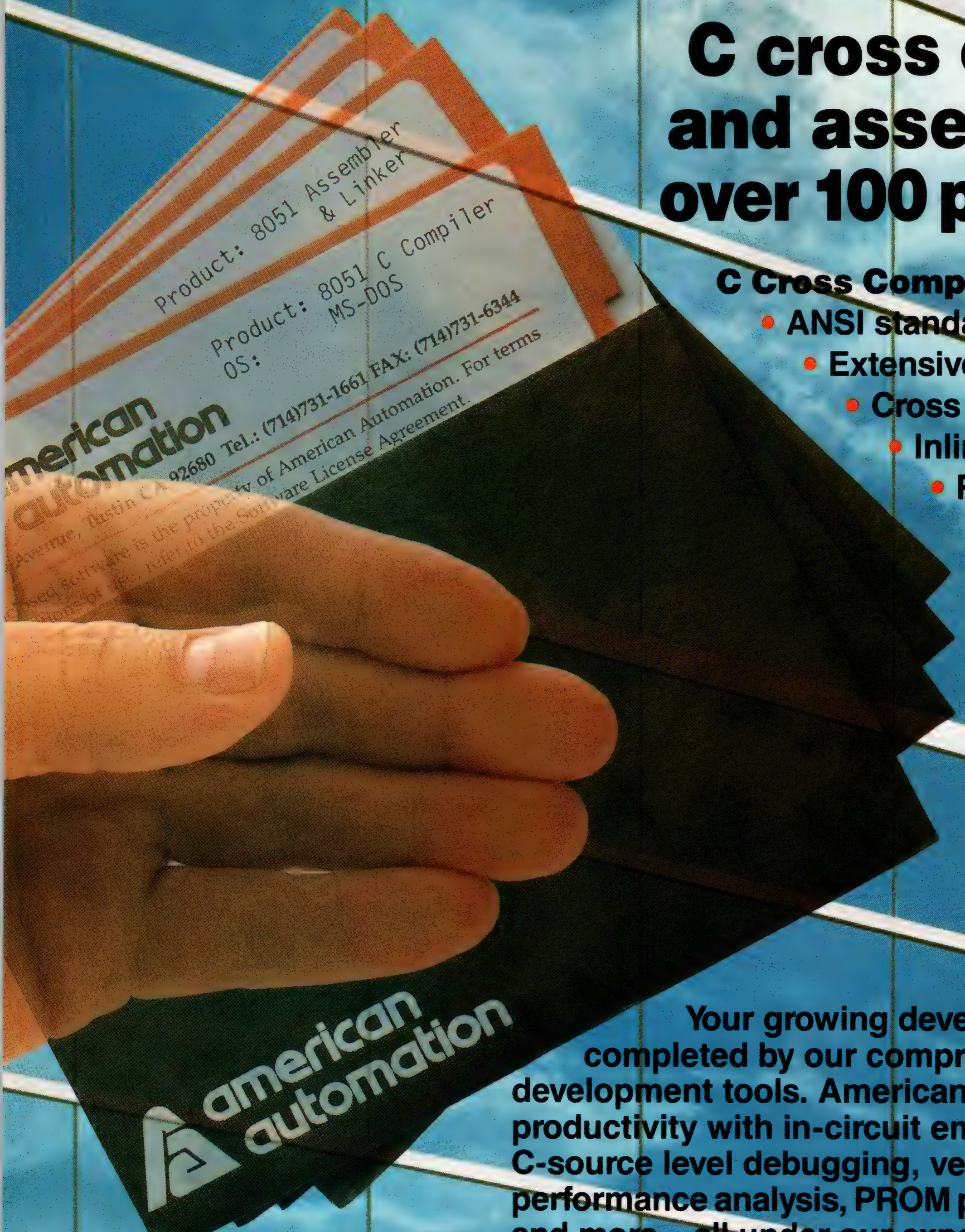
CIRCLE NO. 96



630 Alder Drive • Milpitas, CA 95035 • **(408) 946-9600** • **(800) 622-5020** (Outside CA)

"C" Better.

C cross compilers and assemblers for over 100 processors.


Product: 8051 Assembler & Linker
Product: 8051 C Compiler
OS: MS-DOS
american automation
Avenue, Tustin CA 92680 Tel.: (714)731-1661 FAX: (714)731-6344
Licensed Software is the property of American Automation. For terms
of use, refer to the Software License Agreement.
american automation

C Cross Compilers feature:

- ANSI standard support
- Extensive optimization
- Cross processor portability
- Inline assembly source
- ROMable code
- IBM PC host

Cross Assemblers & Linkers feature:

- Motorola/Intel compatible
- Flexible assembly directives
- User-defined macros
- Linker relocation control
- Boundary checking

Your growing development needs can be completed by our comprehensive family of development tools. American Automation extends productivity with in-circuit emulators, which feature C-source level debugging, versatile trace capability, performance analysis, PROM programming capability and more—all under our expertise and support.

Free demo disk!

See how this feature-rich development environment can benefit you. Call us for your choice of C-Compiler demonstration diskette:

(714) 731-1661

american
automation

Headquarters: 2651 Dow Avenue, Tustin, California 92680-7207, Telephone (714) 731-1661.
European Headquarters: UK Oxford 0993-778991. **Distributors:** Australia 35-601011, Belgium 02-468-1400, France 1-69308050, India 44-417423, Indonesia 02-271-880, Italy 2-50721, Korea 02-784-9942, Spain 1-729-1155, Switzerland 1-435-4111, Taiwan 02-7061271, West Germany/Netherlands/Austria 089-6127087.

EZ-Pro is a trademark of American Automation.

CIRCLE NO. 116

DESIGN IDEAS

EDITED BY CHARLES H SMALL

Power controller switches cycles

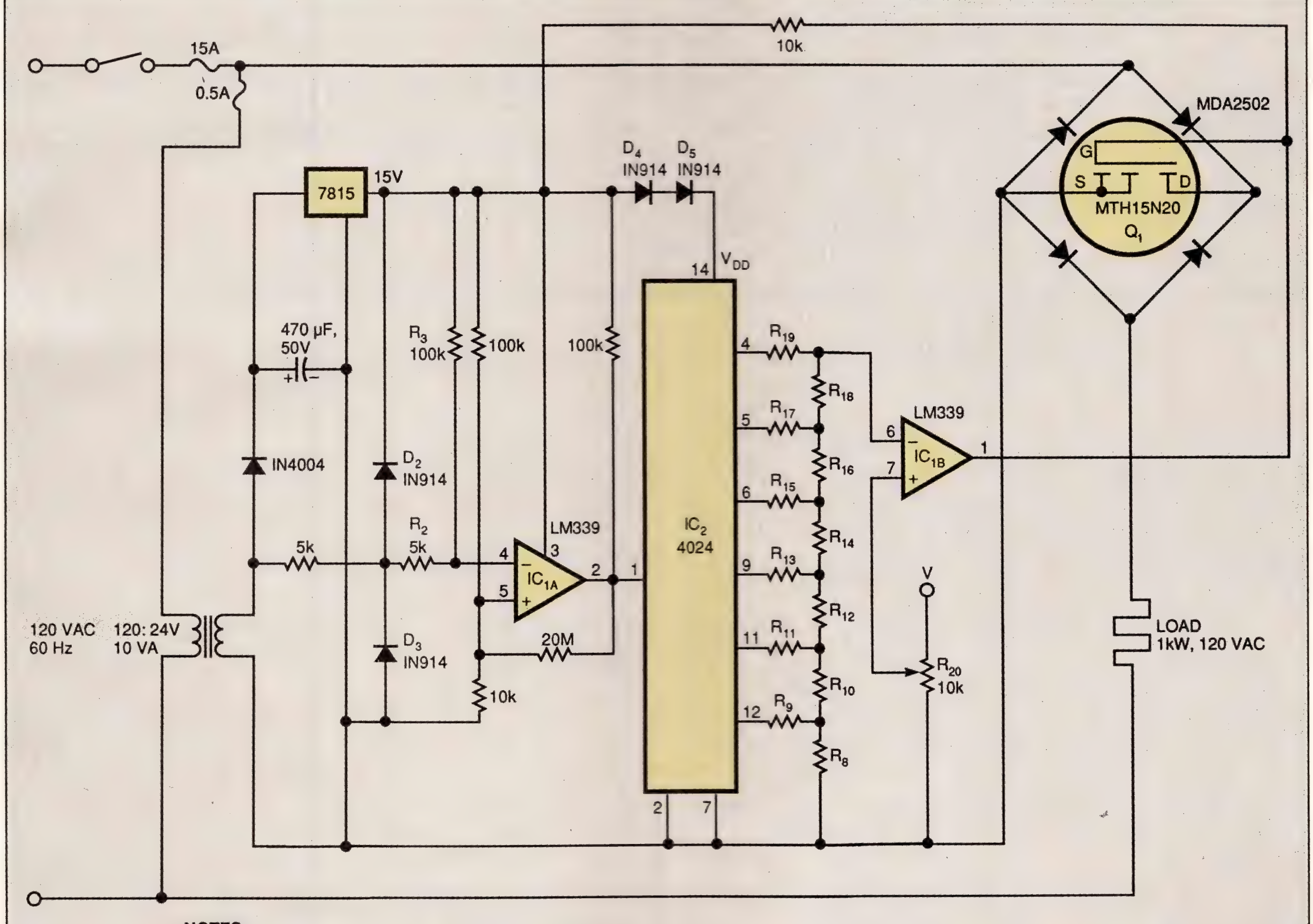
Dennis Eichenberg
Parma Heights, OH

The power controller in **Fig 1** operates over 2^6 complete ac-power cycles. Depending on the setting of R_{20}, the controller delivers a variable number of those cycles to the load and remains off for the remainder of the integral number of cycles. The controller's cycle time at 60 Hz is $2^6/60$ sec = 1.067 sec; the circuit's resolution is one cycle (1/60 sec). The circuit features zero-crossover switching.

IC_{1A} and its associated components are a zero-crossing detector. D_2, D_3, R_2, and R_3 clamp the voltage at pin 5 of IC_{1A}. IC_{1A}'s output, whose transitions occur only at the zero crossings of the input ac waveform, clocks counter IC_2. IC_2's output drives the staircase generator, R_{19}, through R_8. When R_{19}'s voltage matches or exceeds that of potentiometer R_{20}, IC_{1B} turns off power MOSFET Q_1 for the remainder of the controller's cycle.

D_4 and D_5 reduce the supply voltage of IC_2 to ensure that the voltage at pin 6 of IC_{1B} is less than the voltage at pin 7 when R_{20} is at its maximum setting. This voltage difference ensures that Q_1 will be fully on at this setting. **EDN**

To Vote For This Design, Circle No. 746



NOTES:
1. ALL RESISTORS 1/4 W, 5% UNLESS SPECIFIED OTHERWISE.
2. R_8, R_9, R_{11}, R_{13}, R_{15}, R_{17}, R_{19} 100k, 1/4 W, 1%.
3. R_{10}, R_{12}, R_{14}, R_{16}, R_{18} 50k, 1/4 W, 1%.

*Fig 1—**This zero-crossing-switching** power controller has a 1-cycle resolution.*

Spice models 3-terminal reference

Steven C Hageman
Calex Manufacturing Co, Pleasant Hill, CA

Motorola's model for its TL431 programmable voltage reference has 10 transistors. Give Spice that many transistors to digest, and it'll have convergence problems. The Spice model in **Fig 1** and **Listing 1** simulates the device simply and accurately.

Q1 models the device's cathode saturation. With Q1's forward B set to 1, RIN adjusts the reference's input

Listing 1—TL431 Spice model

```
***************************************************************************
;
.SUBCKT TL431 1 2 3
;             ^ ^ ^
;             : : :
;             : : +---- Cathode
;             : +------ Anode
;             +-------- Reference
;
; Usage: XNAME A K R TL431
;
; This Subcircuit Accurately Models The Following Parameters (@ 25 Deg C):
;      * Reference Voltage
;      * Cathode - Anode Voltage Vs. Current for -100mA to +100mA Range
;      * Reference Voltage Vs. Cathode to Anode Voltage
;      * Reference Input Bias Current
;      * Dyanmic Impedance @ < 10 kHz
;      * Voltage Gain Vs. Frequency
;      * Open Loop Saturation Voltage
;
***************************************************************************

; Reference Input Stage
Q1         3   1   10     QINPUT
RIN        10    2        500K

; Internal Reference Voltage
VR         20    2        DC 1.7791 ; Macro Representation Of TL431 Reference
RVR        20    2        1G

; Pole/Zero Modeling
GM         0,30  10,20    1               ;DC Gain Of This Stage = 1E6 = GM * RGM
RGM        30    0        1MEG

; Poles/Zeros - Pole 1 = RGM & CP1, 10KHZ
;               Pole 2 = RP2 & CP2, 60KHZ
;               Zero 1 = CP1 & RZ1, 500KHZ
CP1        30    40       15.9P
RZ1        40    0        20K
RP2        30    50       10MEG
CP2        50    0        0.265P

; Gain Stage Voltage Clamp
DC         0     30       DCLAMP

; Output Stage
GO         3,2   50,0     2.5U          ; Cathode Current Source, Gain / 1E6
DR         2     3        DNOM          ; Substrate Diode

.MODEL DNOM D(IS=100E-15 RS=7)
.MODEL DCLAMP D(IS=0.1)
.MODEL QINPUT NPN(BF=1 VAF=11.15)

.ENDS  TL431
```

bias current. The Q1's Early voltage models the variation of the reference voltage with cathode voltage (~−1 mV/V).

The circuit comprising VR and RVR represents the TL431's internal bandgap reference. The bandgap voltage is 1.7791V to correct for the V_{BE} drop of Q1.

GM, RGM, and diode DC together model a gain stage having a gain of 1,000,000. This high gain eases clamping large voltages to one quadrant with low-voltage-drop diode DC. With DC's saturation current at 100 mA, the diode has a very low voltage drop. Current source GO, at 2.5 μS (micromhos), models the TL431's transconductance. DC's circuit, along with GO, correctly models the TL431's ability to only sink current.

CP1, CP2, RGM, RZ1, and RP2 model the TL431 transfer function's ac poles and zeros. You can do such modeling manually by fitting the device's actual poles and zeros to the model's on reactance graph paper.

Diode DR (see definition of DNOM in **Listing 1**) models the reverse current characteristics of the TL431.

To Vote For This Design, Circle No. 747

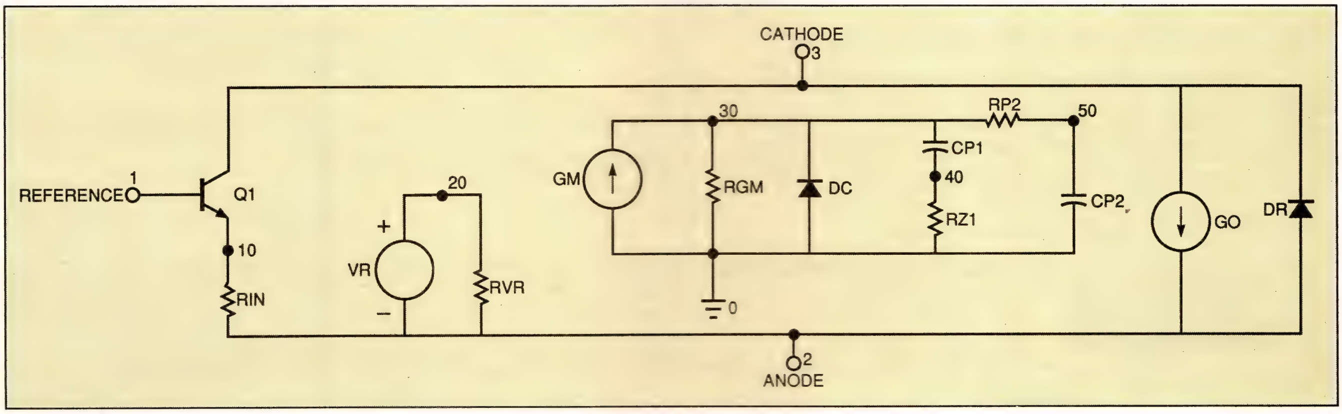


Fig 1—This Spice model for the TL431 programmable voltage reference is as accurate as its manufacturer's model but is much simpler.

Dual-port RAM doubles bit width

Jim Handy
Integrated Device Technology, Salinas, CA

Few fast static RAMs are available in a × 16-bit organization, and none are available in a × 32-bit organization. However, if you need a wide, fast (but not-too-deep) RAM, consider paralleling both ports of a dual-port RAM.

Because the ports of a dual-port RAM are completely independent and asynchronous, you can treat them as though they were two RAMs in a single package and simply parallel them. **Fig 1** shows how to provide unique addresses to the ports of a dual-port RAM by hard-wiring a high and low to the most significant address lines of the right and left ports, respectively.

To Vote For This Design, Circle No. 748

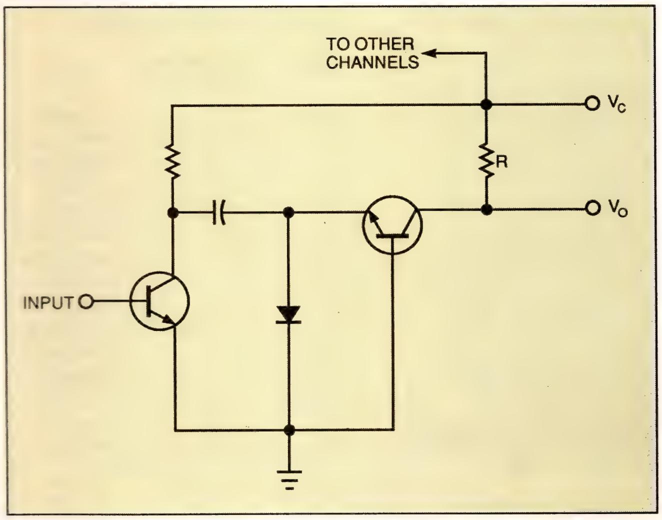
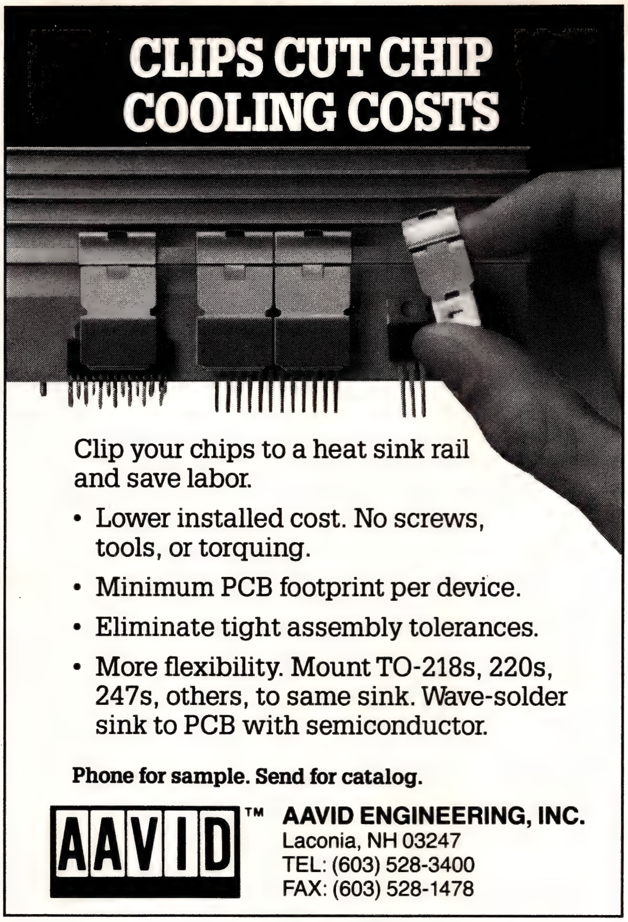


Fig 1—Simple hardwiring transforms a dual-port RAM into a single-port RAM having twice the memory width—but half the memory depth—of the dual-port device.



CLIPS CUT CHIP COOLING COSTS

Clip your chips to a heat sink rail and save labor.

- Lower installed cost. No screws, tools, or torquing.
- Minimum PCB footprint per device.
- Eliminate tight assembly tolerances.
- More flexibility. Mount TO-218s, 220s, 247s, others, to same sink. Wave-solder sink to PCB with semiconductor.

Phone for sample. Send for catalog.

AAVID™ **AAVID ENGINEERING, INC.**
Laconia, NH 03247
TEL: (603) 528-3400
FAX: (603) 528-1478

CIRCLE NO. 10

RAF ELECTRONIC HARDWARE, INC.

We Can Help You Get a Handle On Things

Whether your equipment goes onto racks, panels, cabinets or drawers, RAF offers a variety of attractive, functional handles. Available in round, oval and round offset shapes, these handsome handles can give a modern, hi-tech look to your equipment. They come in a wide variety of widths and heights. If you can't find the right size, we'll produce handles to your prints. Handles are just one of thousands of electronic hardware types listed in our 160-page catalog. Write or call for a copy today.

RAF Electronic Hardware
95 Silvermine Road, Seymour, CT 06483
(203) 888-2133 FAX: (203) 888-9860

CIRCLE NO. 11

F/V converter has variable slope

Cezary Rudnicki
Institute of Electronics, Warszawa, Poland

You can vary the slope of the response of this frequency-to-voltage converter **(Fig 1)** by changing the voltage at its control input, V_C.

The circuit's output for a constant frequency, f_C, is

$$V_O = V_C - RI_2, \text{ where } I_2 = CV_Cf_{IN}.$$

If the input frequency changes by δf, then the ac component of the output signal is

$$V_{OAC} = IV_CCR\Delta f$$

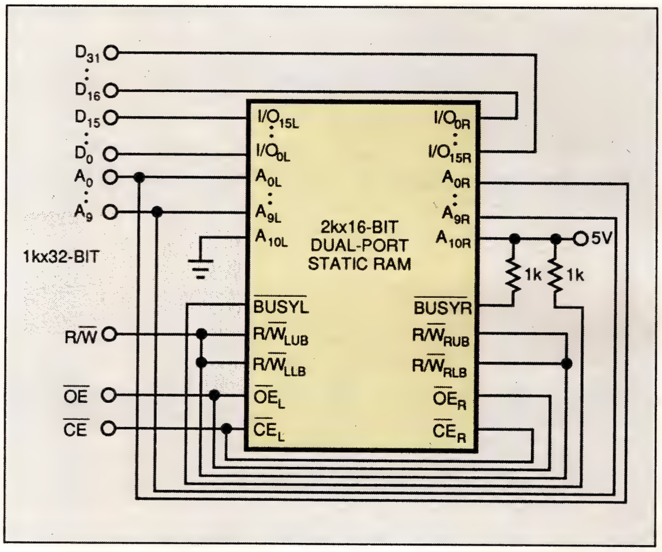


***Fig 1—The V/F converter's response** is programmable via control voltage V_C.*

and the amplitude of the output signal is

$$|V_O| = V_CCR\Delta f_{MAX}.$$

Because the slope of the dynamic voltage-to-frequency function is

$$\text{Slope} = V_CCR,$$

you must filter the V_C signal and stabilize the circuit's power supply to minimize spurious responses. EDN

To Vote For This Design, Circle No. 749

from 99¢

dc to 2000 MHz amplifier series

SPECIFICATIONS

MODEL	FREQ. MHz	GAIN, dB 100 MHz	GAIN, dB 1000 MHz	GAIN, dB 2000 MHz	GAIN, dB Min. (note)	• MAX. PWR. dBm	NF dB	PRICE $ Ea.	Qty.
MAR-1	DC-1000	18.5	15.5	—	13.0	0	5.0	0.99	(100)
MAR-2	DC-2000	13	12.5	11	8.5	+3	6.5	1.50	(25)
MAR-3	DC-2000	13	12.5	10.5	8.0	+8 ☐	6.0	1.70	(25)
MAR-4	DC-1000	8.2	8.0	—	7.0	+11	7.0	1.90	(25)
MAR-6	DC-2000	20	16	11	9	0	2.8	1.29	(25)
MAR-7	DC-2000	13.5	12.5	10.5	8.5	+3	5.0	1.90	(25)
MAR-8	DC-1000	33	23	—	19	+10	3.5	2.20	(25)

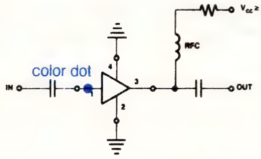
NOTE: Minimum gain at highest frequency point and over full temperature range.
- 1dB Gain Compression

☐ +4dBm 1 to 2 GHz

designers amplifier kit, DAK-2

5 of each model, total 35 amplifiers

only $59.95



Unbelievable, until now…tiny monolithic wide-band amplifiers for as low as 99 cents. These rugged 0.085 in.diam.,plastic-packaged units are 50ohm* input/output impedance, unconditionally stable regardless of load*, and easily cascadable. Models in the MAR-series offer up to 33 dB gain, 0 to +11dBm output, noise figure as low as 2.8dB, and up to DC-2000MHz bandwidth.

*MAR-8, Input/Output Impedance is not 50ohms, see data sheet. Stable for source/load impedance VSWR less than 3:1

Also, for your design convenience, Mini-Circuits offers chip coupling capacitors at 12 cents each.†

Size (mils)	Tolerance	Temperature Characteristic	Value
80 × 50	5%	NPO	10, 22, 47, 68, 100, 220, 470, 680, 1000 pf
80 × 50	10%	X7R	2200, 4700, 6800, 10,000 pf
120 × 60	10%	X7R	.022, .047, .068, .1μf

† Minimum Order 50 per Value

- Designers kit, kcap-1,50 pieces of each capacitor value, only $99.95

finding new ways…
setting higher standards

Mini-Circuits

A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

C113-Rev. D

Design Entry Blank

$100 Cash Award for all entries selected by editors. An additional $100 Cash Award for the winning design of each issue, determined by vote of readers. Additional $1500 Cash Award for annual Grand Prize Design, selected among biweekly winners by vote of editors.

To: Design Ideas Editor, EDN Magazine
Cahners Publishing Co
275 Washington St, Newton, MA 02158

I hereby submit my Design Ideas entry.

Name ____________________

Title ____________ Phone ________

Company ____________________

Division (if any) ____________________

Street ____________________

City ____________ State ________

Country ____________ Zip ________

Design Title ____________________

Home Address ____________________

____

Social Security Number ____________________
(Must accompany all Design Ideas submitted by US authors)

Entry blank must accompany all entries. Design entered must be submitted exclusively to EDN, must not be patented, and must have no patent pending. Design must be original with author(s), must not have been previously published (limited-distribution house organs excepted), and must have been constructed and tested.

Exclusive publishing rights remain with Cahners Publishing Co unless entry is returned to author or editor gives written permission for publication elsewhere.

In submitting my entry, I agree to abide by the rules of the Design Ideas Program.

Signed ____________________

Date ____________________

ISSUE WINNER

The winning Design Idea for the December 7, 1989, issue is entitled "Bidirectional switch replaces relays," submitted by Benno Dreier of Standard Elektrik Lorenz AG (Stuttgart, W Germany).

Your vote determines this issue's winner. All designs published win $100 cash. All issue winners receive an additional $100 and become eligible for the annual $1500 Grand Prize. **Vote now**, by circling the appropriate number on the reader inquiry card.

RS-232C ports survive insults

Charles Allen
Maxim, Sunnyvale, CA

An RS-232C port in your design provides an open door for overvoltages and overcurrents from the outside world. The extra components in **Fig 1** will protect an RS-232C port against even 117V ac.

Two devices, a Tranzorb transient suppressor and a positive-temperature-coefficient resistor (PTC), protect each I/O line. Unlike fuses, this protection circuit resumes normal operation as soon as the insult stops.

The transient suppressors shunt the initial surge of current to ground while the PTC resistors heat up and achieve a high resistance (about 0.2 sec). The output line's transient suppressor is a ±15V model; the input line's suppressor is a ±30V model so as not to interfere with normal ±5-to-±15V RS-232C signals. General Semiconductor (Tempe, AZ) and General Instruments (Hicksville, NY) sell Tranzorbs.

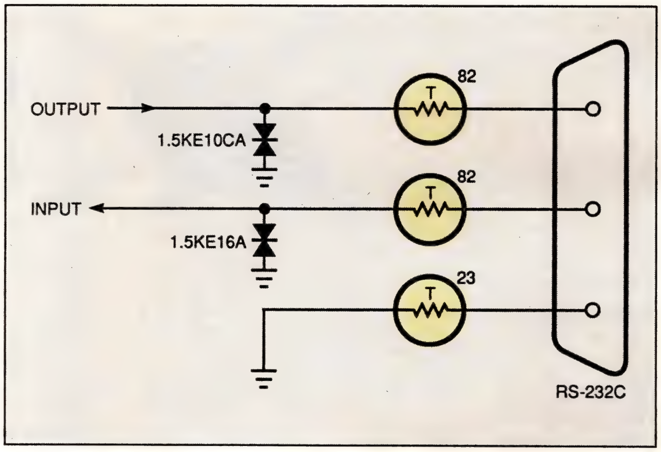


***Fig 1—Simple devices** added to an RS-232C port will protect it from insults—even 117V ac.*

The 82Ω PTC resistors in the I/O lines have no significant effect on RS-232C signals. However, the ground return takes a 23Ω unit to avoid excessively changing the ground reference that IC_1 sees. Midwest Components (Muskegon, MI) makes PTC resistors.

EDN

To Vote For This Design, Circle No. 750

LINEAR TECHNOLOGY

DESIGN NOTES

Number 32 in a series from Linear Technology Corporation March, 1990

A Simple Ultra-Low Dropout Regulator

Jim Williams

Linear voltage regulators with low dropout characteristics are a frequent requirement, particularly in battery powered applications. It is desirable to maintain regulation until the battery is almost entirely depleted. Regulator dropout limits significantly impact useful battery life, and as such should be minimized. Figure 1 shows dropout characteristics for a monolithic regulator, the LT1085. The <1.5V dropout performance is about twice as good as standard monolithic regulators. In many cases this device will serve nicely, but applications requiring lower dropout mandate a different approach.

Figure 2's simple regulator has only 85mV dropout at 2.5A — a 13× improvement. At lower currents dropout decreases to vanishingly small values. This circuit is particularly applicable in battery driven lap top computers, where multi-output power supplies are used. In operation, the LT1431 shunt regulator adjusts its output ("collector") to whatever value is required to force circuit output to 5V. The LT1431's internal trimming eliminates the usual feedback resistors and trimpots. Q1, the pass element, runs as a voltage overdriven source follower. This configuration offers the lowest possible dropout voltage,* although it does require a +12V bias source for Q1's gate. This +12V source is commonly present in lap top computers and similar devices because of disc drive and peripheral power requirements. Power drain on the +12V supply is a few milliamperes.

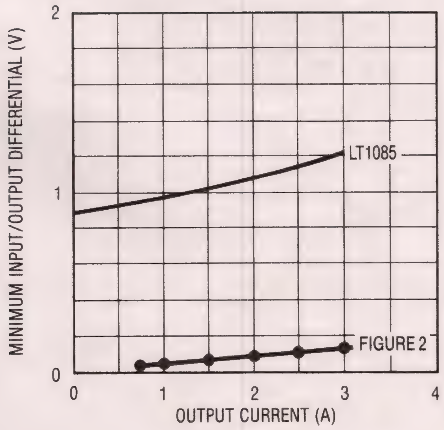
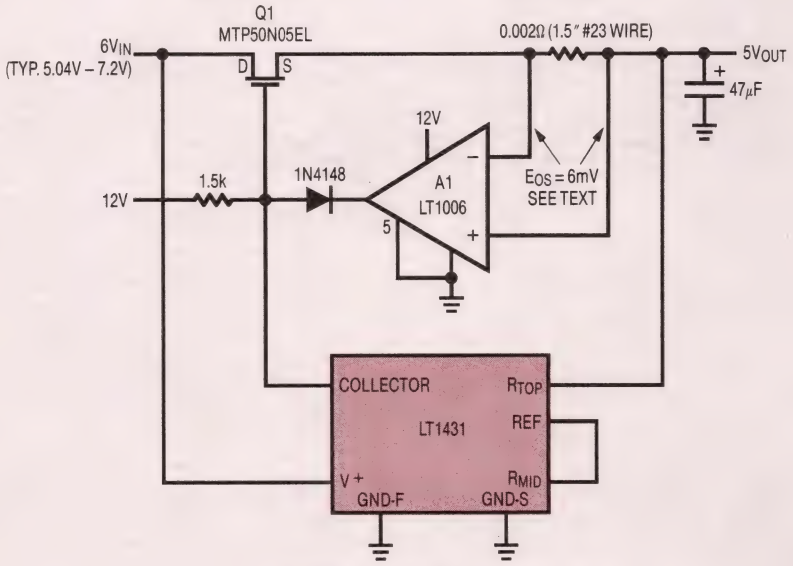


Figure 1. Dropout Performance for a Low Dropout Monolithic Regulator vs Figure 2



CONNECT ALL ⏚ LABELED RETURNS TO A SINGLE POINT AT THE 6VIN SOURCE

Figure 2. Ultra-Low Dropout Regulator

---

*A detailed discussion of various methods for achieving low dropout appears as Appendix A (" Achieving Low Dropout") in LTC Application Note 32, "High Efficiency Linear Regulators."

Providing short circuit protection without introducing significant loss requires care. A1 achieves this by sensing across a 0.002Ω shunt (1.5″ of #23 wire). This introduces only 6mV of drop at the circuits 3A current limit threshold. A 6mV current limit trip point is derived by grounding A1's offset pin 5. The 6mV input offset generated at A1 by doing this is stable over time, temperature and unit-unit variation, and substitutions for A1 are not advisable. Currents beyond 3A cause A1 to pull low, stealing Q1's gate drive and shutting off the regulators output. Under overload conditions A1 and Q1 form a well controlled linear current control loop with smooth limiting. Figure 3 details dropout characteristics. Results for the MTP50N05EL MOSFET specified for Q1 show only 85mV dropout, decreasing to just 8mV at 0.25A. For comparison, data for some higher resistance transistors also appears.

Q1's source follower connection makes regulator dynamics quite good compared to common source/emitter approaches. Figure 4 shows no load (Trace A low) to full load (Trace A high) response. Regulator output (Trace B) dips only 200mV and recovers quickly with clean damping. The positive slew recovery time is due to the 1.5kΩ bias resistor acting against Q1's input capacitance (Trace C is Q1's gate). Quicker response is possible by a reduction in this value, although current drain from the +12V supply will increase. The value used represents a good compromise. Transient recovery for load removal is also well controlled.

This regulator offers a simple solution to applications requiring extremely low dropout over a range of output currents. The performance, low parts count and lack of trimming make it an attractive alternative to other approaches. For reference, pertinent information on construction of wire shunts appears in Figures 5 and 6.

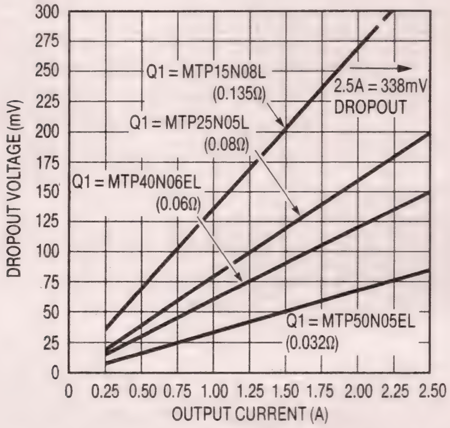


Figure 3. Dropout Characteristics for Figure 2. Q1's Saturation Directly Influences Performance.

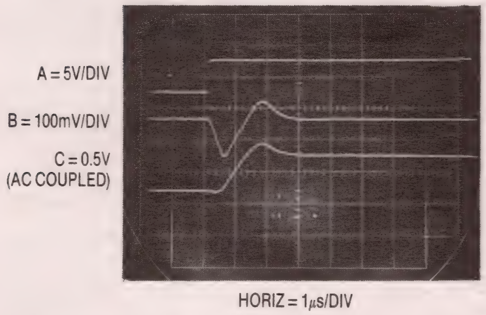


Figure 4. Transient Response for a Full Load Step. Follower Connection Provides Clean Dynamics.

WIRE GAUGE	μΩ/INCH
10	83
11	100
12	130
13	160
14	210
15	265
16	335
17	421
18	530
19	670
20	890
21	1000
22	1300
23	1700
24	2100
25	2700

Figure 5. Resistance vs Size for Various Copper Wire Types

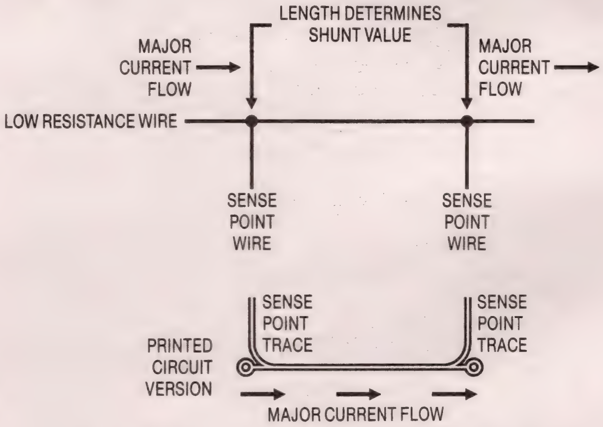


Figure 6. Detail of a Low Resistance Current Shunt

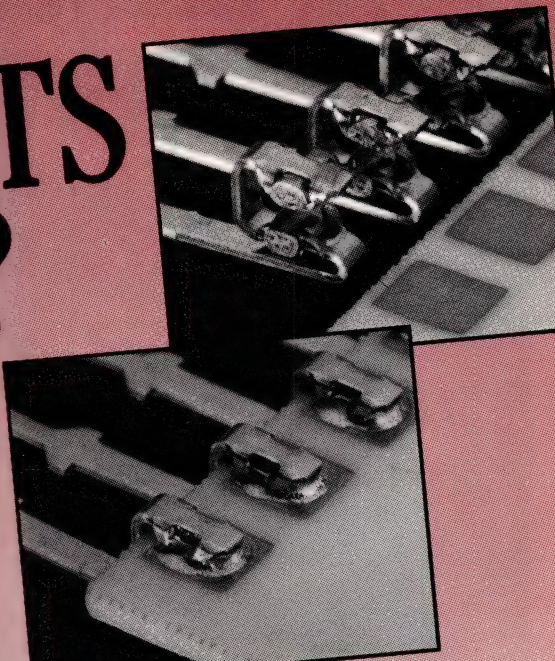
For literature on low dropout regulators, call **(800) 637-5545**. For applications help, call (408) 432-1900, Ext. 445.

Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7487 • (408) 432-1900
FAX: (408) 434-0507 • TELEX: 499-3977

IM/GP 290 165K

© LINEAR TECHNOLOGY CORPORATION 1990

PERFECT SOLDER JOINTS EVERY TIME?



NAS solder and flux bearing edge clips make it easy and economical

By providing direct contact between solder preforms and conductor pads, NAS edge clips with our unique "Claw" grip design assure 100% solderability. A wiping action occurs as the clips are inserted in position, either manually or with a lead attach machine. Interference fit holds NAS clips firmly in position, and top and bottom preforms are reflowed in one operation. Precisely the right amounts of solder and flux and the shape of the "Claw" control solder flow without solder stops. Wicking and bridging are eliminated. The result is perfect mechanical and electrical bonding every time.

Solder and flux bearing edge clips from NAS have proven to be the industry's most efficient, economical and reliable interconnects and the most effective solution to the problem of thermal mismatch in surface mount applications. Fewer assembly steps . . . dramatic reduction in rework . . . lower overall costs . . . increased product reliability — these are some of the major advantages.

NAS offers a complete line of solder and flux bearing edge clips, including .100, .075 and .050 centerlines for both through-hole and surface mounting of chip carriers and hybrids. In addition, we offer our years of specialized experience to help you develop the best solutions to your interconnect problems.

Flux in the preforms and our exclusive "Claw" grip design make the difference. NAS solder and flux bearing edge clips are the only interconnects that will give you *perfect solder joints every time!*

For complete details and our new catalog, call or write:

NAS Electronics, 381 Park Street, Hackensack, NJ 07602.
Tel. 201/343-3156; FAX 201/343-4883.

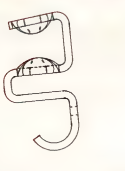
CIRCLE NO. 98

NAS
ELECTRONICS

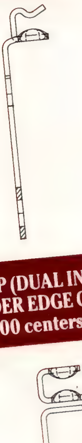
an Interplex Industries company

Some recent additions to the extensive NAS line of solder and flux bearing edge clips:

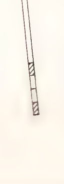
J-LEAD SURFACE MOUNT EDGE CLIP FOR CHIP CARRIERS & HYBRIDS
Claw design, solder bearing .050 centers



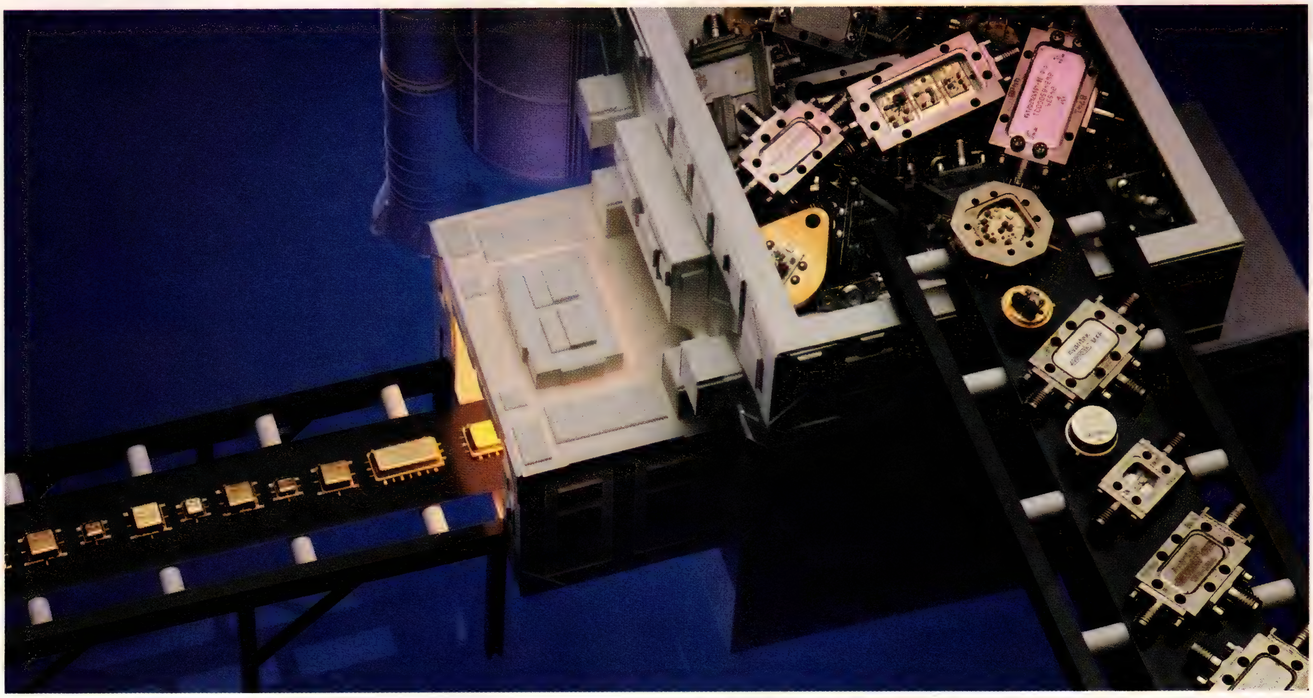
STANDARD DIP (DUAL INLINE PACKAGE) SINGLE SOLDER EDGE CLIP
Claw design .100 centers



STANDARD DIP (DUAL INLINE PACKAGE) DOUBLE SOLDER EDGE CLIP
Claw design .100 centers



PACK MORE PERFORMANCE INTO YOUR SYSTEM...



With PlanarPak™ Microwave Surface Mount Components... DC to 18 GHz

Your next microwave system needs more functions in less space. You're ready for the advantages of microwave surface mount technology (SMT)... Avantek's PlanarPak™ components. You'll get smaller size†... lighter weight...increased board density...and, circuits on both sides of the board. Your design team can put the system you need together faster...with lower risk and more control, with off-the-shelf PlanarPak components. More than thirty different high performance PlanarPak components provide DC to 18 GHz coverage. All are 50 ohm matched for easy microstrip integration. Avantek offers the widest range of microwave functions in surface mount packages—

- Amplifiers—.01 to 18.0 GHz
- Attenuators—.1 to 2.0 GHz
- Detectors—.02 to 6.0 GHz
- Limiting Amplifiers—.01 to 1.0 GHz
- Mixers—.05 to 2.5 GHz
- Switches—.01 to 2.0 GHz

—with more functions on the way. PlanarPak components make complete surface mount microwave systems a reality.

Designed for High Volume Applications in Demanding Environments

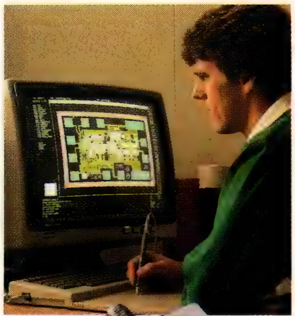
These hermetically sealed, thin-film MIC components are designed for rugged operating environments...missiles... smart munitions...expendables ...and RPVs. Wherever size and performance are critical. PlanarPak products are ideal for automated manufacturing. A proven technology...in volume production today at Avantek.

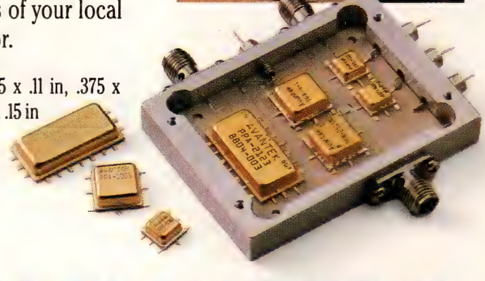
SMT Application Assistance and Off-the-Shelf Delivery...

Avantek, the world leader in microwave SMT, offers a comprehensive selection of literature, test fixtures, and technical assistance. And, all PlanarPak components are in stock at your local Avantek distributor for immediate delivery. Contact us today to receive PlanarPak products literature and the name and address of your local Avantek distributor.

Avantek Regional Offices

North America
Eastern: (301) 381-2600
Central: (708) 358-8963
Western: (805) 373-3870
Europe: (44) 276-685753
Asia: (01) (408) 943-5484





†Three sizes: .25 x .25 x .11 in, .375 x .375 x .15 in and .4 x .8 x .15 in

AVANTEK

CIRCLE NO. 69

NEW PRODUCTS

CAE & SOFTWARE DEVELOPMENT TOOLS

Benchmarks to Measure Computing Capability

- *10 engineering and scientific benchmarks*
- *Endorsed by 12 computer-system vendors*

The SPEC (Systems Performance Evaluation Cooperative) Benchmark Suite, release 1.0 is a set of tests to quantify and compare the performance of computer systems. The benchmarks, adapted from real applications, measure both integer and floating-point computations. Release 1.0 contains more than 150,000 lines of C and Fortran code. The Cooperative estimates that a typical high-end workstation should require 2 to 3 hours to execute the complete benchmark. The 10 applications that comprise the benchmarks are Unix-based and designed to run on as many different computer systems as possible. SPEC 1.0 runs on VMS computers as well. Whereas the current suite of tests evaluate CPU performance, future suites will measure disk, graphics, and communications performance. Benchmark tape, $450; SPEC quarterly newsletter, containing benchmarking results from member companies, $150/year.

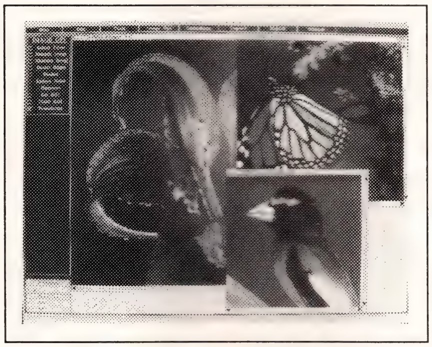
SPEC, c/o Waterside Associates, 39510 Paseo Padre Pkwy, Suite 350, Fremont, CA 94538. Phone (415) 792-2901. **Circle No. 356**

Call-Back Modem Software

- *Dial-in/call-back technique thwarts intruders*
- *Runs on all DEC Ultrix systems*

Modem-Safe protects your DEC Unix-based servers and workstations by hanging up on users that call in on modem lines. After breaking this initial connection, the software instructs the DEC hardware to call the user back at a preregistered phone number. This number verifies the physical location of the caller and minimizes the likelihood of random access. The software features several security modes, including transparent access for UUCP (Unix-to-Unix copy), a suite of phone-line-interface software for exchanging electronic-mail communications. Modem-Safe runs during log-in processing and recognizes calls for UUCP communications. The software connects directly or via LAT (Local Area Transport) terminal servers to most industry-standard modems. A 4-modem license, including two years of free updates and technical support, $2500. Site licenses are available as well.

Compu-Science Development Co, 1634 Roll St, Santa Clara, CA 95050. Phone (408) 241-4140. **Circle No. 357**



Apollo-Based Imaging Software

- *Accepts several file input formats*
- *16- and 256-level gray, line-art, and 24-bit color-image data*

Pixel!Perfect is an image manipulation program. The software runs on the DN-2500, DN-3500, and DN-4500 workstations using 1280×1024-pixel 19-in. monochrome monitors and the 1024×800-pixel and 1280×1024-pixel 8-plane color graphics subsystems. Among the file formats that Pixel!Perfect accepts and puts out are Apollo's graphic primitive resource and tagged-image file format (TIFF). Additionally, the software accepts data from several scanners, including several of the Truvel scanners, and supports color and grayscale Postscript. Using the software, you can manipulate images in multiple windows with cut, paste, copy, clear, zoom, and invert-color commands. You can sharpen, smooth, insert shadows, or reduce noise over parts of the image. Image transformations are also possible as are color conversions or image dithering. Software for a node with a scanner, $2995; software for a network-image manipulation node, $1995.

Mentalix Inc, 1701 N Collins, Suite 235A, Richardson, TX 75080. Phone (214) 234-6611. FAX 214-644-2143. **Circle No. 358**

Graphics Software Tool Kit

- *Runs on IBM PCs and compatibles with IBM EGA or VGA*
- *Calculates shading, highlights, and surface penetrations*

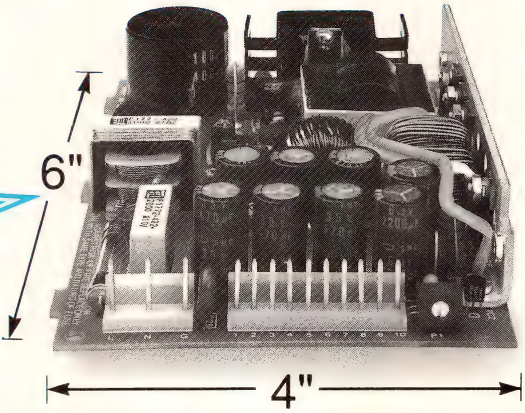
3-D Computerscape uses scan-coherence algorithms and assembly-language programming to create images. After creating the images, you can edit them and display them using perspective, animation, 3-D rotations, and multiple-view options. The PC-based software package comes with demonstration files and programs with examples of applications in robotics, animation, and solids modeling. You can incorporate the software's functions and procedures into Turbo Pascal programs; the software is compatible with Turbo Pascal versions 5.0 and 5.5. $89.

Abbot, Foster, & Hauserman Co, 44 Montgomery St, San Francisco, CA 94014. Phone (800) 562-0025; in CA, (415) 955-2711.

Circle No. 359

UNIVERSAL 85-264 V INPUT 65 W SWITCHER

One To Four Outputs



1.125" Total Height

Never Worry About Input Voltage Again

The SRW-65 Series from Integrated Power Designs delivers 65W in a 6" x 4" x 1.125" package. The power supply accepts any input voltage within the range of 85 to 264 V AC without any modifications.

The New SRW Series Features

- ☐ Less than 1% P-P Ripple & Noise on All Outputs
- ☐ 0° to 50° Convection Cooled Operating Temp.
- ☐ 100% Burn-In with Power Cycling
- ☐ Snap-Lock or Screw-Down I/O Connectors
- ☐ Submitted for Testing to UL1950, CSA 22.2 No. 234-M, and EN 60950 (TUV)
- ☐ Level "B" Input Filter
- ☐ One-Year Warranty
- ☐ 21 Standard Models
- ☐ Over-Voltage Protection
- ☐ 75-80% Efficiency
- ☐ 20 mS Hold-Up Time

Reserve Your Evaluation Unit or get additional information on our many standard, ready-to-ship AC-DC and open frame DC-DC power supplies. For standard, modified, and custom capabilities, call **(609) 896-2122**.

QUADS:	Output 1	Output 2	Output 3	Output 4
SRW-65-4001	+5V@5.0A	–5V@3.0A	+12V@2.0A	–12V@2.0A
SRW-65-4002	+5V@5.0A	+12V@1.0A	+12V@2.0A	–12V@2.0A
SRW-65-4003	+5V@5.0A	+24V@1.0A	+12V@2.0A	–12V@2.0A
SRW-65-4004	+5V@5.0A	–5V@3.0A	+15V@2.0A	–15V@2.0A
SRW-65-4005	+5V@5.0A	+24V@1.0A	+12V@2.0A	–5V@2.0A
SRW-65-4006	+5V@5.0A	+24V@1.0A	+15V@2.0A	–15V@2.0A
TRIPLES:				
SRW-65-3001	+5V@5.0A		+12V@3.0A	–12V@1.0A
SRW-65-3002	+5V@7.0A		+12V@2.0A	–12V@2.0A
SRW-65-3003	+5V@7.0A		+15V@2.0A	–15V@2.0A
SRW-65-3004	+5V@5.0A	–5V@4.0A	+12V@2.0A	
SRW-65-3005	+5V@5.0A	–5V@4.0A	+24V@1.0A	
DUALS:				
SRW-65-2001	+5V@7.0A			–5V@5.0A
SRW-65-2002	+5V@7.0A		+12V@3.0A	
SRW-65-2003	+12V@3.0A			–12V@2.5A
SRW-65-2004	+15V@2.5A			–15V@2.0A
SRW-65-2005	+5V@7.0A		+24V@1.5A	
SINGLES:				
SRW-65-1001	+5V@10.0A			
SRW-65-1002	+12V@5.4A			
SRW-65-1003	+15V@4.3A			
SRW-65-1004	+24V@2.7A			

Other output combinations available, please consult factory.

We're here to help you meet your power challenges.

INTEGRATED POWER DESIGNS

9C Princess Road ☐ Lawrenceville, NJ 08648 ☐ Tel: (609) 896-2122 ☐ Fax: (609) 895-1738

CIRCLE NO. 99

Thermal-Analysis Software

- *Runs on IBM PCs and compatibles, or the Macintosh*
- *Provides temperature and heat-flow maps*

The Sauna thermal-analysis software program uses an interactive menu system. The software, which runs on both the Macintosh II, and IBM PCs and compatible computers, allows for heat sources that manage wattage, junction and case temperatures, and thermal resistances. In addition, the software models all heat-transfer modes: convection, conduction, and radiation. Sauna features modeling capability that accounts for enclosures, heat sinks, circuit boards, and plates. The materials library contains properties for aluminum alloys, plastics, and circuit-board materials. The software also contains thermal properties for standard semiconductor packages. Edit commands available within the thermal-analysis package let you change housing materials, move heat sources, and reposition circuit boards before beginning another analysis run. Sauna standard package, $995; advanced version that allows handling of unusual configurations, $2995.

Tatum Labs Inc, 3917 Research Park Dr, B-1, Ann Arbor, MI 48108. Phone (313) 663-8810.

Circle No. 360

PLD Design Software

- *Converts logic design to JEDEC fuse map*
- *Runs on IBM PCs and compatibles*

You can use truth tables, Boolean equations, and state diagrams to enter your PLD designs into proLogic, a software tool for the vendor's PLDs. The software's compiler performs logic minimization, error recognition, and creates the JEDEC fuse map. ProLogic also uses the JEDEC file to create a functional device model that you can use to execute test vectors. The software contains the simulator so you can exercise the model. The user interface and methodology mimic those of common third-party software tools. This version of the software is an exclusive subset of the proLogic PLD design software developed by Inlab Inc (Broomfield, CO). You can obtain a free copy of the PC-based software through the end of March by requesting item SRPU001 from the vendor's Customer Response center.

Texas Instruments Inc, Semiconductor Group (SC-971), Box 809066, Dallas, TX 75380. Phone (800) 232-3200, ext 700.

Circle No. 361

You've seen them all before. Everyday items you may not think about much. But, they have something in common: they all carry "data." Information that's important to you. And their size makes it easy for you to transport that data from place to place. In your pocket, your wallet, your briefcase, on your person, whatever's convenient.

Data that opens things up...identifies you to others...accesses machines, services, and physical areas...allows you to do repetitive tasks faster and easier...and more.

The need for new "portable data carriers" in today's world of miniaturization and convenience is growing all the time.

What does all this mean to you as an electronics design professional?

We'd like to tell you. Read on...

DataKey®

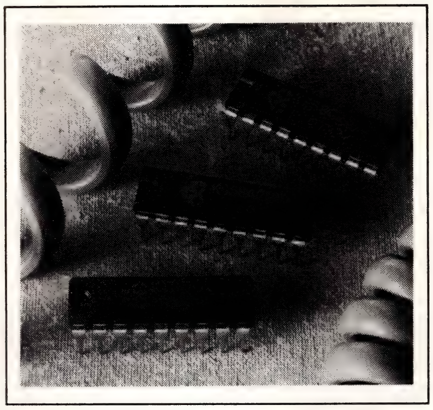
Datakey, Inc. • 407 West Traveler's Trail, Minneapolis, MN 55337 U.S.A. • Phone (612) 890-6850 • Fax (612) 890-2726

INTEGRATED CIRCUITS

Telephone Dialer ICs

- *Fabricated in low-power CMOS*
- *Provide tone/pulse/redial functions*

Included in this low-power CMOS family of telephone chips are the KT3170 DTMF receiver, the KS5820 tone/pulse dialer, and the KS5822 and KS5823 DTMF/pulse repertory dialers. Operating from a single 5V supply, the KT3170 receiver uses switched-capacitor filters to separate the high- and low-group tones. All 16 DTMF tone pairs are decoded into a 4-bit digital code. An on-chip clock generator uses a low-cost 3.579545-MHz TV crystal. The switchable KS5820 DTMF/pulse dialer has a 32-digit redial memory and operates from a 2.0 to 5.5V supply. The dual-tone frequencies are derived from a TV crystal. The KS5822 and KS5823 repertory dialers operate in either a tone- or pulse-dialing mode. They contain a 32-digit RAM for redialing and derive all dial-tone frequencies from a TV crystal. Compared with the KS5823, the KS5822 provides four additional signals, including dial-pulse ratio select and on-hook store inhibit. Both devices operate from 2.0 to 5.5V supplies. KT3170 in an 18-pin DIP, $1.30; KS5820 in an 18-pin DIP, $0.85; KS5822 in a 22-pin DIP and KS5823 in an 18-pin DIP, $1.35 (100).



Samsung Semiconductor, 3725 N First St, San Jose, CA 95134. Phone (408) 434-5400. TLX 339544.

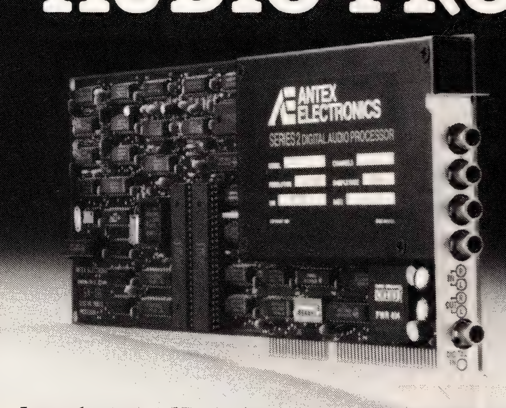
Circle No. 371

64-Channel Driver

- *80V push-pull outputs*
- *40-MHz data rate*

Designed for use in flat-panel displays, plotters, and printers, the HV77 64-channel HVCMOS driver chip features 80V push-pull outputs. Functionally, the HV77 is a cascadable serial-to-parallel converter with four simultaneously clocked shift registers. Each shift register runs at a speed in excess of 10 MHz at 5V, giving an equivalent data-throughput rate of more than 40 MHz. Logic controls include latch enable, output blanking, and

AUDIO PRO



Introducing...CD quality, stereo high fidelity, digital audio you record and playback on your PC-AT/286/386/Model 30 or compatible.

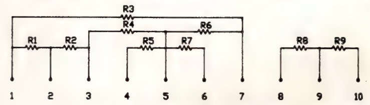
Featuring...real time direct to disk data transfer...16-bit resolution...20Hz to 20kHz audio response...0.005% THD...6.25 to 50kHz programmable sample rate...92dB dynamic range...90db s/n...digital input...4 to 1 ADPCM compression.

Use for digital audio recording, editing, mastering and transmission in broadcasting, entertainment systems, film production, audio/visual presentations and interactive CDI/DVI systems.

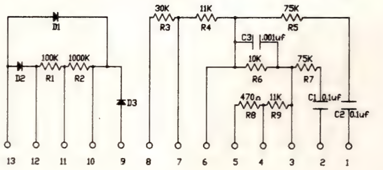
If you're an audiophile with microcomputer resources call 1-800-338-4231 (ex. CA.) for details on our Audio Pro...the Series 2/Model SX-10.

ANTEX ELECTRONICS

16100 S. Figueroa St. • Gardena, CA 90248 • Tel (213) 532-3092 • FAX (213) 532-8509



CUSTOM THICK FILM NETWORKS



Fast turnaround on U.S. made DIPs and coated/molded SIPs. • Unlimited schematics combining resistors, inductors, capacitors and diodes. • Complete capabilities from design through production. • Lead lengths up to 0.290". • Special performance ranges, plus production and testing to M83401 levels.

Call or Fax your requirements to:

TECHNO DIVISION
DALE ELECTRONICS, INC.
. . . a VISHAY Company
7803 Lemona Ave. • Van Nuys, CA 91405-1139
Phone (818) 781-1642 • FAX (818) 781-8647

polarity reversal. In addition, a direction pin allows data to flow either clockwise or counterclockwise. This feature is useful in display applications when devices mounted on opposite sides of the panel must shift their drives in opposite directions. Standby current for the device is <50 nA. The HV77 is available in plastic or ceramic 80-pin quad flatpacks. Plastic, $8.80 (1000).

Supertex Inc, 1225 Bordeaux Dr, Sunnyvale, CA 94088. Phone (408) 744-0100. FAX 408-734-5247.

Circle No. 372

Current-Feedback Op Amp

- *Has 150-mA output current*
- *Bandwidth is 45 MHz*

The OPA603 current-feedback op amp has a nearly constant 45-MHz bandwidth at closed-loop gains from 1 to 10, and settles to 0.1% in 50 nsec. The op amp also provides 150 mA of output current, a significant advantage for line-driving and fast capacitance-charging applications. The device can deliver ±10V signals at a slew rate of 1000V/µsec into 150Ω loads. Operating from ±4.5 to ±18V supplies, the OPA603 comes in an 8-pin DIP and is specified for the industrial temperature range.

Burr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. FAX 602-889-1510.

Circle No. 373

µP Supervisory Chips

- *Monitor the 5V supply*
- *Provide power-on reset function*

The Max698, a power-on reset controller, and the MaxX699, a power-on reset controller with a watchdog timer, monitor the condition of the 5V supply in µP-based systems. Both devices supply a 140-msec reset pulse during power-up, power-down, or low-voltage conditions. The Max699's watchdog input monitors µP activity and pulls the reset output low if the watchdog input isn't toggled within one second. You can disable this feature by leaving the watchdog input floating. The devices come in 8-pin DIPs and in 16-pin SO packages. The SO-packaged versions have reset-output and watchdog-output pins, which are not available in DIP versions. Max698, from $2; Max699, from $2.30 (100).

Maxim Integrated Products, 120 San Gabriel Dr, Sunnyvale, CA 94086. Phone (408) 737-7600.

Circle No. 374

Welcome to the new world of portable data carriers. Small, pocket-sized devices that carry electronically recorded information so it's convenient to retrieve and use. For a variety of real-world applications.

They're made of tough, static-resistant, specially formulated plastic—to withstand rough handling and retain your data even when exposed to dust, dirt, moisture, magnetic fields, and other environmental hazards. In other words, to survive in your pocket—and in even more rugged environments.

Our expertise in packaging semiconductor memories and microprocessors has led to many advances in transportable data. Including the access device for the U.S. government's secure phone system. Hundreds of thousands of these data carriers are already in use. Today, our line of *standard products* includes several types of portable data carriers:

☐ *Serial Memory Keys:* with 1, 2, or 4Kbit capacity.
☐ *Parallel Memory Keys:* For high speed or direct microprocessor interface, from 16K to 512Kbit capacity, 8-bit word length.
☐ *Memory Cards:* credit-card type devices, with up to 4Mbits storage including chip-on-card or edge-connect.
☐ *Low-Cost Personal ID and MemoryTokens:* ideal for many office or industrial uses, from 26 bit to 1Kbit capacities.
☐ *And more:* including combination mechanical / electronic keys, and mil-spec type plug-in devices.

They're machine readable, smaller than floppy disks, require less power and cost less than disk drives, can store more data than mag-stripe cards . . . and they're much more rugged.

To learn more about the new wave in data portability, call toll-free today. (For custom applications, read on . . .)

DataKey®
Advanced Solutions in Portable Data Technology.™

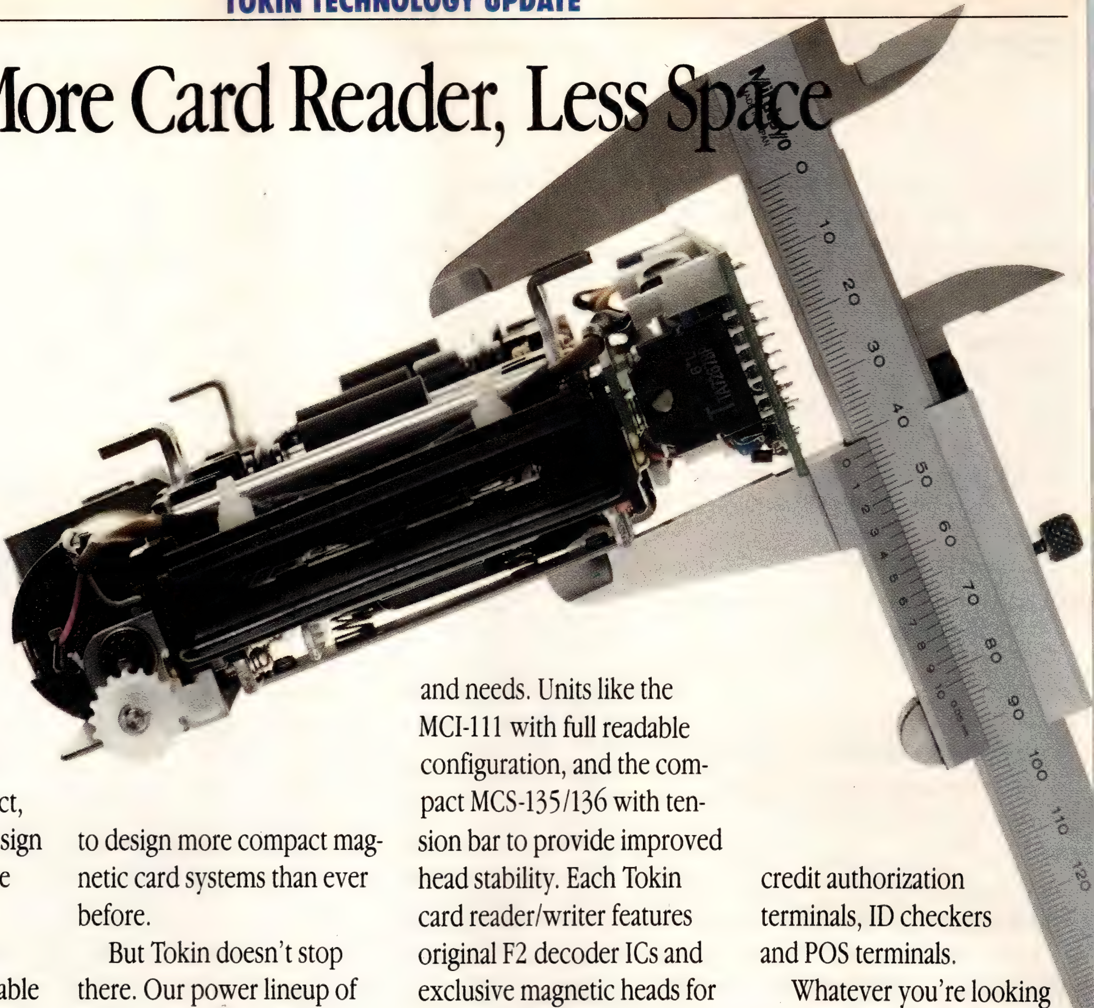
Call 1-800-328-8828
Need it fast? We'll fax it.

Datakey, Inc. • 407 West Travelers Trail, Minneapolis, MN 55337 U.S.A. • Phone (612) 890-6850 • Fax (612) 890-2726

CIRCLE NO. 14

TOKIN TECHNOLOGY UPDATE

More Card Reader, Less Space



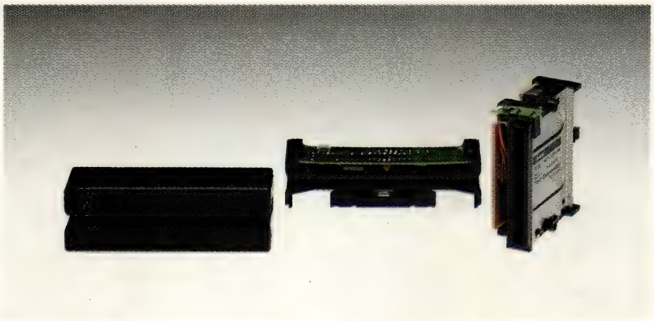
It's here. The designer's dream. A motorized card reader so small, so compact, so lightweight, you can design it into any system you dare imagine.

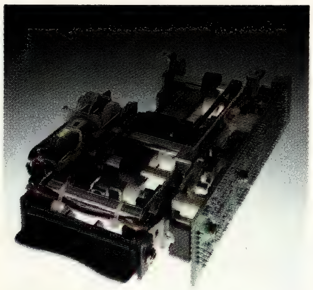
Tokin's new MCA-1601 boasts the kind of impeccable design that only Tokin, with a full half-century of magnetic engineering achievements, can produce.

The MCA-1601 overcomes card readers' biggest drawback—size. Slim (46mm) and lightweight (700g), it gives you the power and flexibility to design more compact magnetic card systems than ever before.

But Tokin doesn't stop there. Our power lineup of card readers and writers offers the perfect choice for a vast range of specifications and needs. Units like the MCI-111 with full readable configuration, and the compact MCS-135/136 with tension bar to provide improved head stability. Each Tokin card reader/writer features original F2 decoder ICs and exclusive magnetic heads for superior performance over a range of applications including strip card readers for credit authorization terminals, ID checkers and POS terminals.

Whatever you're looking for in a card reader/writer, Tokin delivers improved performance and flexibility, and the opportunity to design card systems that match your most demanding specifications. Check us out.





Manual magnetic card reader/writer unit

Model	Card standard	Features	Dimensions (mm)
MCS-135	ISO 3554 Track 1 and 2	One way, double track: simultaneous reading	100×32×32.5 (with cover)
MCS-136	ISO 3554 Track 2 and 3	One way, double track: simultaneous reading	
MCI-111	ISO 3554 Track 2	Magnetic card insertion system	67×65×24

Motorized magnetic card reader/writer unit

Model	Card standard	Features	Dimensions D×W×H (mm)
MCA-1601	Accepts all standards	Extremely thin and half the volume*	183×139×45.4

*Compared with conventional Tokin models.

TOKIN

Tokin Corporation

Hazama Bldg., 5-8, Kita-Aoyama 2-chome, Minato-ku, Tokyo 107, Japan
Phone: 03-402-6166 Fax: 03-497-9756 Telex: 02422695 TOKIN J

Tokin America Inc.

155 Nicholson Lane, San Jose, California 95134, U.S.A.
Phone: 408-432-8020 Fax: 408-434-0375
Chicago Branch
9935 Capitol Drive, Wheeling, Illinois 60090, U.S.A.
Phone: 708-215-8802 Fax: 708-215-8804

Tokin Electronics (H.K.) Ltd.

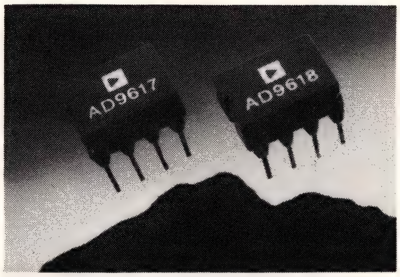
Room 806 Austin Tower, 22-26A, Austin Avenue,
Tsimshatsui, Kowloon, Hong Kong
Phone: (3) 679157~9 Fax: (3) 7395950
Taiwan Liaison Office
7/F-2, No. 200, Sec. 3, Hsin-Yi Road, Taipei
Phone: (02) 7059310~1 Fax: (02) 7015650

München Liaison Office

Elisabethstraße 21, 8000 München 40, Bundesrepublik Deutschland
Phone: (089) 271 75 22 Fax: (089) 271 75 67
Telex: 5 24 537 tokin d

You can reach our agents by phone: Denmark (03) 63 3830; France (1) 45-34-7535; Italy (0331) 67-8058; Spain 729-1155; Switzerland (01) 830-3161

CIRCLE NO. 108



Wideband Op Amps

- *160- and 190-MHz bandwidths*
- *Have low harmonic distortion*

Using current-feedback circuitry, the AD9617 and AD9618 monolithic op amps achieve small-signal bandwidths of 190- and 160-MHz, respectively, at closed-loop gains of 3V/V and 10V/V. Pin-compatible with competitive devices, which specify distortion at only one frequency, these op amps are specified at frequencies of 4.3, 20, and 60 MHz. When compared at 20 MHz with 2V p-p input signals, the AD9617's maximum −59 and −61 dBc second- and third-harmonic-distortion components surpass the industry's previous best by 14 and 11 dBc, respectively. Under identical conditions, the AD9618's second- and third-harmonic components are −55 and −62 dBc. Other specifications include an input offset of 1.1 mV max, typical CMR of 60 dB, 0.01% differential gain, and 0.02° differential phase. In miniDIPs, SO packages, or ceramic DIPs in three temperature ranges, from $11.55.

Analog Devices, Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 329-4700.

Circle No. 375

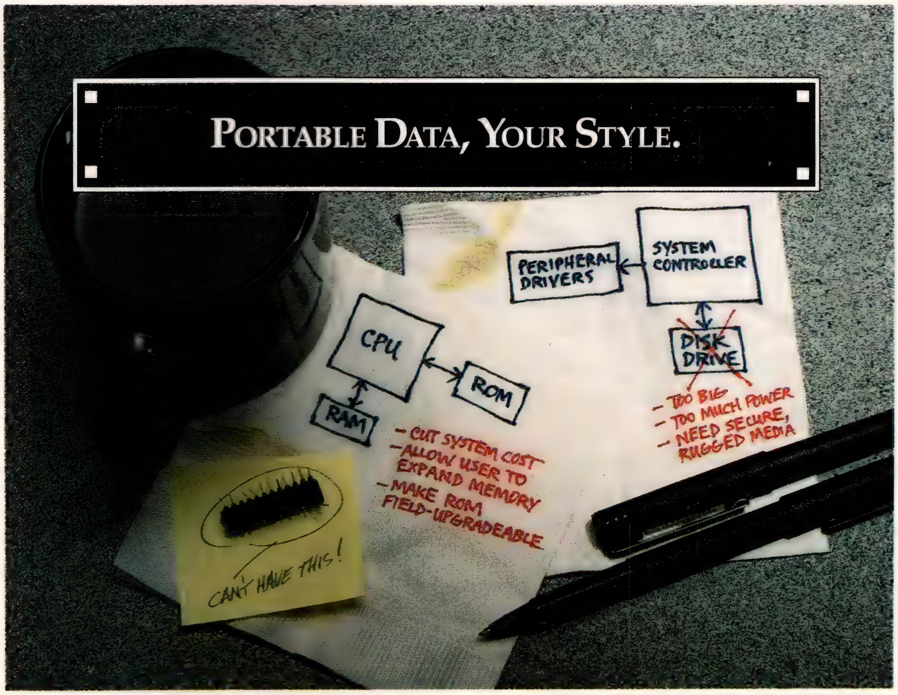
Dual 8-Bit A/D Converter

- *Samples to 25M samples/sec*
- *Has two 11-MHz buffer amplifiers*

The SP1072 hybrid IC contains two 25-MHz, 8-bit flash A/D converters with 3-state outputs, two 11-MHz buffer amplifiers, and an on-board voltage reference. The device comes in a 42-pin hermetic package, consumes 2.6W of power, and is available in military versions. Key specifications include a sampling rate of 25M samples/sec for sampling signals of as high as 11 MHz, an S/N ratio of 46 dB, and differential and integral nonlinearity of ±1 LSB max. Aperture delay is 4 nsec, and cross-channel isolation is 54 dB. Uncommitted buffer amplifiers enable adjustable ranges for unipolar and bipolar modes. The hybrid IC operates from ±5 and ±12V supplies. With MIL-STD-883C screening, $580 (100).

Sipex Corp, 6 Fortune Dr, Billerica, MA 01821. Phone (508) 663-9691.

Circle No. 376



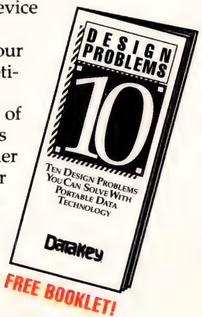
To meet your unique system design needs, we also manufacture *custom* portable data devices. For applications with limited system space, limited power availability, and other tough requirements. With end-uses as diverse as computer and communications system security, industrial process control, automotive, and medical electronics, to name a few.

Anywhere a simple, reliable, easy-to-use data carrier can help you improve user or system convenience...save keystrokes...reduce operator errors...improve security ...load and transfer equipment operating parameters... collect data at remote sites... you name it.

Portable data is a proven, expanding technology that you as an electronics design professional should know about. So, we've written a booklet. In it, we describe some of the many benefits you can realize by adopting portable data technology in your system designs, no matter what your volume needs:

- ☐ Save valuable system space
- ☐ Reduce system power requirements
- ☐ Cut costs... low-cost memory expansion
- ☐ Improve system security
- ☐ Speed data transfer, with more convenient data handling
- ☐ Make ROM upgrades quicker, easier
- ☐ Simplify your system
- ☐ Ruggedize your I/O device
- ☐ Reduce I/O device size, weight
- ☐ Differentiate your product competitively

For a free copy of the booklet, call us toll-free. The sooner you do, the sooner you can start putting portable data to use *your* way.


DESIGN PROBLEMS
10
Ten Design Problems You Can Solve With Portable Data Technology
Datakey
FREE BOOKLET!

Call 1-800-328-8828
Need it fast? We'll fax it.

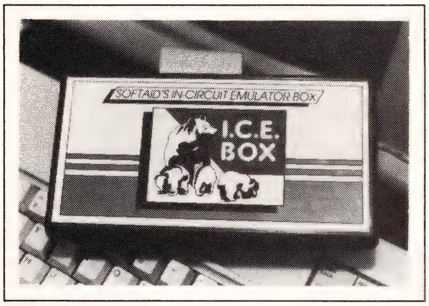
Datakey®
Advanced Solutions in Portable Data Technology.™

Datakey, Inc. • 407 West Travelers Trail, Minneapolis, MN 55337 U.S.A. • Phone (612) 890-6850 • Fax (612) 890-2726

CIRCLE NO. 15

NEW PRODUCTS

TEST & MEASUREMENT INSTRUMENTS



Z80 Emulator

- *Priced below $600*
- *Usable with ASCII terminals*

The Z80 Icebox is a small (6×8 in.) in-circuit emulator for the classic, 8-bit μP. After you connect the emulator to the RS-232C port of a computer or ASCII terminal, it operates with Z80s clocked as fast as 8 MHz. The emulator has 2^{16} hardware breakpoints and 32 "printpoints," which you can use to investigate the status of a running program without affecting its execution. When single stepping, you can exclude portions of your code and, thus, run long-delay routines and event handlers at full speed. Emulator, $595; optional source-level debugger, $695.

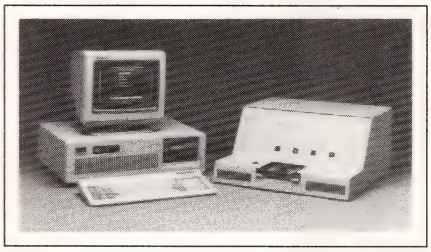
Softaid Inc, 8930 Route 108, Columbia, MD 21045. Phone (800) 433-8812; in MD, (301) 964-8455. FAX 301-596-1852. TWX 640-265-2092. **Circle No. 362**

Data-Acquisition Software

- *Supports vendor's IBM PC and PS/2 I/O boards*
- *Permits DMA transfers to 250k samples/sec*

Global Lab software for IBM PCs and PS/2 computers supports the vendor's DT2801, DT2821, and DT2901 Series A/D data-acquisition boards. When the computer's speed permits, this software will transfer data to and from memory under DMA control at 250k samples/sec. Most third-party software that controls the vendor's boards operates them at much lower speeds. The menu-driven program displays data at high speed during acquisition and performs statistical analysis on the displayed data. It lets you view files in multiple windows; scale displays and gridlines; and export window parameters as well as edited and statistical data to industry-standard software packages. $995.

Data Translation, 100 Locke Dr, Marlboro, MA 01752. Phone (508) 481-3700. FAX 508-481-8620. TLX 951646. **Circle No. 363**

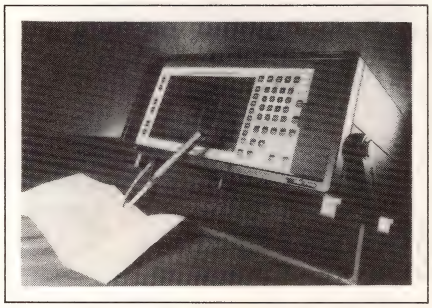


Benchtop Mixed-Signal Device Tester

- *Performs parametric and functional tests*
- *Hosted by IBM PC/AT-compatible computer*

The PTS-1010 is an IBM PC/AT-based benchtop tester that makes parametric and functional tests on mixed-signal (analog/digital) ICs. The tester has a shared-resource architecture that allows you to augment its capabilities with external equipment. Included in the system are four programmable power supplies, 22 digital I/O pins, 28 analog pins, a 16-bit reference DAC, and 11 relay-matrix drivers. You program the tester in a specially extended version of Basic. The vendor offers a library of programs to test 1600 types of devices. From $53,500. Delivery, 60 days ARO.

Sage Enterprises Inc, 795 San Antonio Rd, Palo Alto, CA 94303. Phone (800) 843-8259; in CA, (415) 493-9146. FAX 415-493-0811. TLX 296122. **Circle No. 364**



Audio-Frequency Analyzer

- *Weighs 22 lbs*
- *Operates from batteries for four hours*

You can carry the Type 2143 frequency analyzer into the field to perform real-time sound or vibration analysis. The input accepts 0.5-Hz to 20-kHz signals from microphones and accelerometers. You can choose among four digital-filter bandwidths—1/1 octave for 16 filter points, 1/3, 1/12, and 1/24 octave—and you can center the filter responses at 384 discrete frequencies across the band. A back-lit LCD shows the spectrum, and there is enough internal nonvolatile memory to retain 512 1/3-octave spectra. If you need more memory, the analyzer has a 3½-in. floppy-disk drive, which records in MS DOS-compatible format. The single-channel unit includes IEEE-488 and RS-232C interfaces. $19,242.

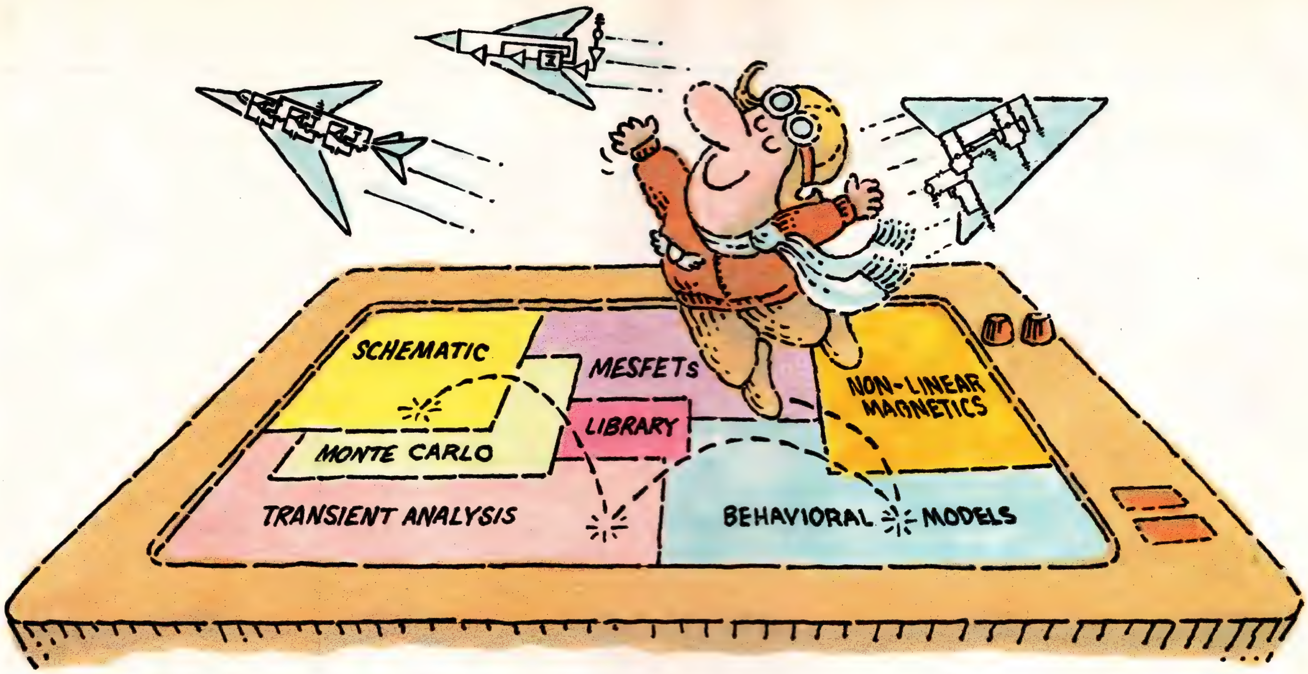
Bruel and Kjaer Instruments Inc, 185 Forest St, Marlboro, MA 01752. Phone (508) 481-7000. FAX 508-485-0519. **Circle No. 365**

Bruel and Kjaer, DK 2850, Naerum, Denmark. Phone (452) 800500. FAX 452-801405. **Circle No. 366**

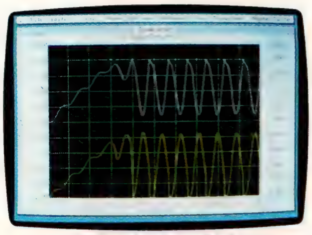
ESD Simulator

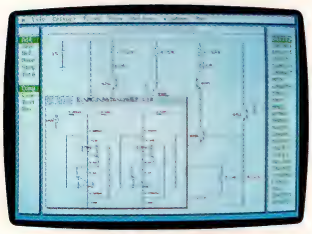
- *Generates HBM pulses to ±8 kV*
- *Complies with MIL-STD-883c, Notice 8, Method 3015.7*

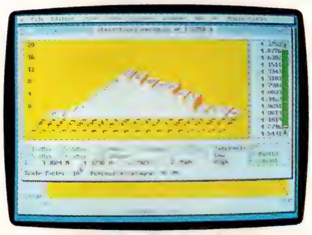
The Model 910 electrostatic-dis-



THE NEW MICRO-CAP III.™ SO YOU CAN TEST-FLY EVEN MORE MODELS.


Transient analysis


Schematic editor


Monte Carlo analysis

It wasn't easy. But we did it. Made the long-time best-selling IBM® PC-based interactive CAE tool even better.

Take modeling power. We've significantly expanded math expression capabilities to permit comprehensive analog behavioral modeling. And, beyond Gummel Poon BJT and Level 3 MOS, you're now ready for nonlinear magnetics modeling. Even MESFET modeling.

Analysis and simulation is faster, too. Because the program's now in "C" and assembly language. That also means more capacity—for simulating even larger circuits.

As always, count on fast circuit creation, thanks to window-based operation and a schematic editor. Rapid, right-from-schematics analysis—AC, DC, fourier and transient—via SPICE-like routines. The ability to combine digital/analog circuit simulations using integrated switch models and parameterized macros. And stepped component values that streamline multiple-plot generation.

And don't forget MICRO-CAP III's extended routine list—from impedance, Nyquist diagrams and BH plots to Monte Carlo for statistical analysis of production yield. The algebraic formula parsers for plotting virtually any function. The support for Hercules, CGA, MCGA, EGA and VGA displays. Output for plotters and laser printers.

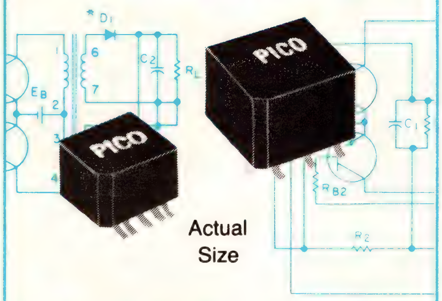
Cost? Still only $1495. Evaluation versions still only $150. Brochure and demo disk still free for the asking. Call or write for yours today. And see how easily you can get ideas up and flying.

spectrum

1021 S. Wolfe Road
Sunnyvale, CA 94086
(408) 738-4387

CIRCLE NO. 109

ULTRA-MINIATURE
SURFACE MOUNT



DC-DC Converter Transformers and Power Inductors

These units have gull wing construction which is compatible with tube fed automatic placement equipment or pick and place manufacturing techniques. Transformers can be used for self-saturating or linear switching applications. The Inductors are ideal for noise, spike and power filtering applications in Power Supplies, DC-DC Converters and Switching Regulators.

- *Operation over ambient temperature range from −55°C to +105°C*
- *All units are magnetically shielded*
- *All units exceed the requirements of MIL-T-27 (+130°C)*
- *Transformers have input voltages of 5V, 12V, 24V and 48V. Output voltages to 300V.*
- *Transformers can be used for self-saturating or linear switching applications*
- *Schematics and parts list provided with transformers*
- *Inductors to 20mH with DC currents to 5.4 amps*
- *Inductors have split windings*

Delivery— stock to one week

SEE EEM, THOMAS REGISTER OR SEND DIRECT FOR FREE PICO CATALOG

PICO Electronics, Inc.
453 N. MacQuesten Pkwy. Mt. Vernon, N.Y. 10552
Call Toll Free 800-431-1064
IN NEW YORK CALL 914-699-5514

CIRCLE NO. 22

charge simulator complies with MIL-STD-883c, Notice 8, Method 3015.7. It generates human-body-model (HBM) pulses to ±8 kV. The unit has manual and automatic test modes, digital readout of peak discharge-pulse amplitude, and a voltage rise time of 11 nsec. The HBM components mount on a plug-in assembly. The unit includes a calibration resistor and has an output that can drive a curve tracer. $5495.

Electro-Tech Systems Inc, 115 E Glenside Ave, Glenside, PA 19038. Phone (215) 887-2196. FAX 215-887-0131. TLX 797137.
Circle No. 367

Optical Signal Source

- *Accepts analog and digital signals to 1G bit/sec*
- *Available with long- and short-wavelength lasers*

The Model 400 is a laser transmitter that you can modulate using high-speed analog and digital signals. The unit operates to at least 1G bit/sec. The vendor can supply the transmitter with a short- or a long-wavelength laser. In the analog mode, the laser is biased to 50% of full output, and the input signal varies the output from zero to at least 90% of the maximum. In the digital mode, you can use a front-panel control to adjust the point on the input waveform where the laser switches on and off. Direct coupling makes the threshold insensitive to the pulse pattern. $3450 to $3850. Delivery, four to six weeks ARO.

Broadband Communications Products Inc, 17E Hibiscus Blvd, Suite 210, Melbourne, FL 32901. Phone (407) 984-3671.
Circle No. 368

Memory Tester

- *Tests DRAMs, SRAMs, ROMs, EPROMs, and EEPROMs*
- *Handles ICs and SIMMs to 16M bytes*

The Model 1000 is an IBM PC-based tester for memory ICs and SIMMs (single in-line memory modules). It uses industry-standard protocols to test dynamic and static RAMs; and masked-programmable, UV-erasable-, and electrically-erasable read-only memories. The parts can hold from 16k bits to 16M bytes and can have access times from 25 to 300 nsec. The tester can accommodate eight ICs at a time. These ICs can be in a variety of through-hole and surface-mount packages. If the device types are unknown, the tester can determine the proper test parameters. The menu- or mouse-driven software permits using the tester for both production testing and engineering characterization. $4000.

Integrated Test Systems, 21621 Kerry Ct, El Toro, CA 92630. Phone (714) 586-0332. FAX 714-586-0636. **Circle No. 369**

Two Microwave Spectrum Analyzers

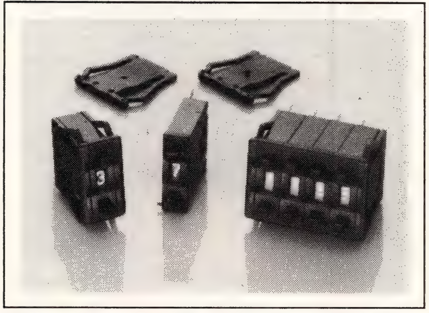
- *Measure levels from −115 to +30 dBm*
- *Operate from 10 kHz to 140 GHz and 100 kHz to 23 GHz*

The units in the MS710 family measure signal levels from −115 to +30 dBm (dB above 1 mW) and display an 80-dB dynamic range. The MS710C covers 10 kHz to 140 GHz, using external waveguide harmonic mixers above 18 GHz; the MS710F covers 100 kHz to 23 GHz. Both units include input attenuators that reduce signal levels by a maximum of 70 dB in 10-dB steps. A series of filters enables you to set the resolution bandwidth from 100 Hz to 3 MHz (−6 dB). The units have IEEE-488 ports and can drive printers and plotters. The vendor supplies many accessories, including tracking generators. MS710C, $25,500; MS710F, $22,140.

Anritsu America Inc, 15 Thornton Rd, Oakland, NJ 07436. Phone (800) 255-7234; in NJ, (201) 337-1111. **Circle No. 370**

NEW PRODUCTS

COMPONENTS & POWER SUPPLIES



Thumbwheel Switches

- *Offer coded output*
- *Have a 10^6 detent life*

Units in the 3P Series of thumbwheel switches offer decimal, BCD, BCD complement, and spdt repeating function coded outputs. The contacts switch 100 mA and carry 1A. Operating voltage levels span 50 mV to 28V dc. The switches will accommodate 100,000 actuations through 360° for a total electrical life of 10^6 detents. Insulation resistance equals $10^9\Omega$, and dielectric strength at sea level measures 500V rms between the common terminal and any output. Switch housings are black or gray ABS, and the pushbuttons are black delrin. Wheels are black 6/6 nylon with white characters. From $3.90 (100). Delivery, six weeks ARO.

C&K Components Inc, 15 Riverdale Ave, Newton, MA 02158. Phone (617) 964-6400. FAX 617-332-2379. **Circle No. 377**

Blue LEDs

- *Available in two power levels*
- *Operate to 80°C*

These blue LEDs employ silicon-carbide technology and are available as discretes or clusters housed in a variety of industry-standard packages. Two power levels are available. The standard chips operate at 20 mA and output 5 mcd for the single-chip versions, and the high-power units operate at 50 mA and have a single-chip output of 10 mcd. The LEDs operate over a −20 to +80°C range and have power dissipations of 170 and 200 mW for standard and high-power units, respectively. Available base styles include flange, bayonet, candelabra, bipin, groove, wedge, teleslide, and wire terminals. $12 to $15 (1000) for standard single-chip LEDs. Delivery, four to six weeks ARO.

Ledtronics Inc, 4009 Pacific Coast Hwy, Torrance, CA 90505. Phone (213) 549-9995. FAX 213-549-4820. **Circle No. 378**

DC/DC Converters

- *Line includes 30 models*
- *Inputs range from 5 to 48V*

The PMI 900 line of dc/dc converters offers you a choice of inputs ranging from 5 to 48V, and provides 5, 9, 12, and 15V outputs. Dual-polarity alternatives are available at the 12 and 15V levels. The converters will deliver a full 5W output over an operating range of −68 to +95°F. Output temperature coefficient equals ±0.03%/°F. The converters are housed in a package that features a standard pc-board pinout and measures 2×2×0.4 in. £25 (500).

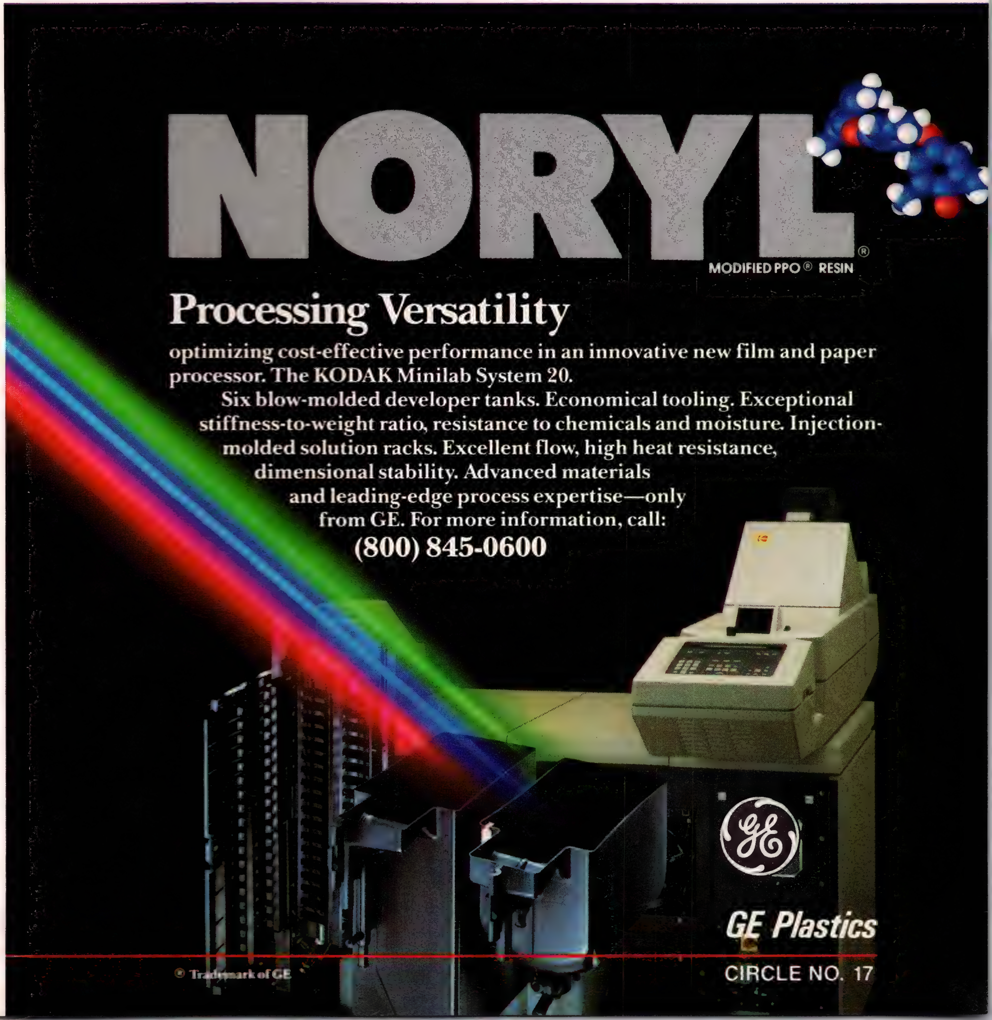
Powerbox Ltd, Mitchell Close, W Portway Industrial Estate, Andover SP10 3TJ, UK. Phone (158) 11920. FAX 158 11811.

Circle No. 379

Fiber-Optic Modules

- *Offer FDDI compliance*
- *ECL compatible*

The DLT1000-FC transmitter and DLR1000-FC receiver offer full


NORYL®
MODIFIED PPO® RESIN

Processing Versatility

optimizing cost-effective performance in an innovative new film and paper processor. The KODAK Minilab System 20.
Six blow-molded developer tanks. Economical tooling. Exceptional stiffness-to-weight ratio, resistance to chemicals and moisture. Injection-molded solution racks. Excellent flow, high heat resistance, dimensional stability. Advanced materials and leading-edge process expertise—only from GE. For more information, call:
(800) 845-0600

GE Plastics

® Trademark of GE

CIRCLE NO. 17

"MATHCAD IS THE BEST THING TO HAPPEN TO THE ENGINEER SINCE THE POCKET PROTECTOR."

— PC Magazine

For problems involving engineering calculations or scientific analysis, the answer is MathCAD®

MathCAD is the only PC-based software package specifically designed to give technical professionals the freedom to follow their own scientific intuition. You decide how to solve the problem – MathCAD does the "grunt work."

- Ends tedious programming and debugging.
- Displays instant answers as you change variables.
- Generates quick plots to help you view results.

MathCAD includes such built-in features as:

- Matrix operations
- Simultaneous equation solver
- Real and complex numbers
- Dynamic error flagging
- Automatic unit conversions
- Greek character set
- Fast Fourier Transform and much more

To find out what MathCAD can do for you, call us today for a **free demo disk: 1-800-MathCAD** (in MA, 617-577-1017). Or write to MathSoft, Inc., One Kendall Square, Cambridge, Massachusetts 02139.

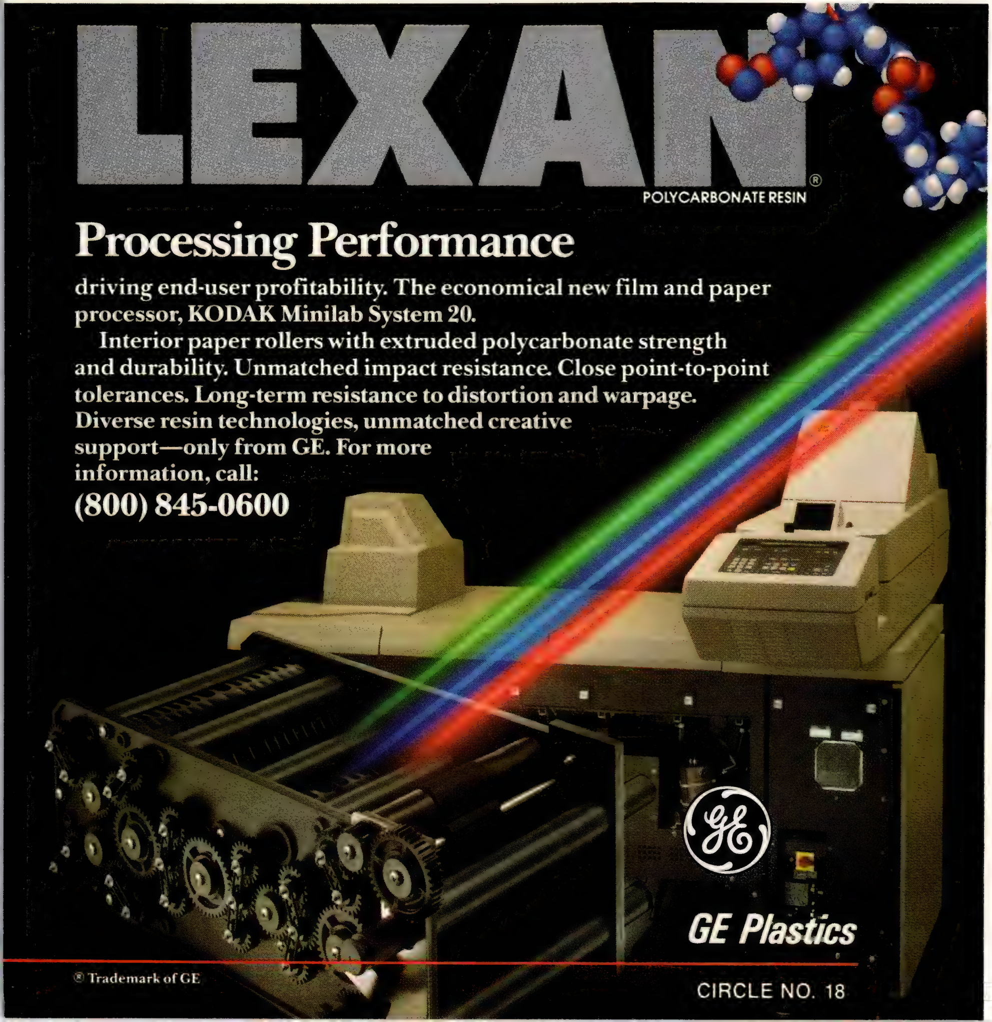
Requires IBM® PC or compatible, 512KB RAM, graphics card.

Math Soft

Σ + √ – = × ∫ ÷ δ

Software Tools for Calculating Minds **#13**

CIRCLE NO. 24



Processing Performance

driving end-user profitability. The economical new film and paper processor, KODAK Minilab System 20.

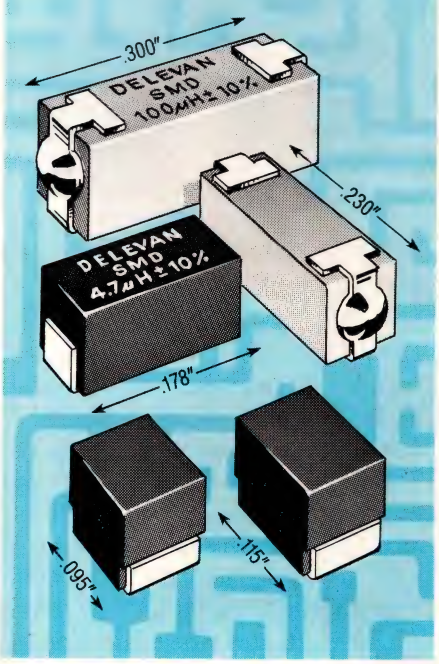
Interior paper rollers with extruded polycarbonate strength and durability. Unmatched impact resistance. Close point-to-point tolerances. Long-term resistance to distortion and warpage. Diverse resin technologies, unmatched creative support—only from GE. For more information, call:

(800) 845-0600

® Trademark of GE

CIRCLE NO. 18

FOR MAXIMUM POPULATION AND PERFORMANCE



YOU CAN RELY ON THE NEW EXPANDED LINE OF DELEVAN SURFACE MOUNTABLE COILS

- New space-saving, low-profile EIA Series 1808, 1210 & 1010 inductors from .010 µH to 150 µH
- Other package sizes in values - 0.22 µH to 1,000 µH
- The most complete offering of surface mountable wire wound coil designs...larger sizes; 2510, 3013 are direct physical and electrical replacements for standard shielded and unshielded inductors such as our 1025 Series
- Designs in 1%, 2%, 3%, 5% tolerances
- MIL approval pending to MIL C-83446
- Patented "J" termination offers proven reliability with any soldering method

DELEVAN / SMD Divisions
AMERICAN PRECISION INDUSTRIES
Electronic Components Group

270 Quaker Road, East Aurora, NY 14052-0449
(716) 652-3600 FAX (716) 652-4814

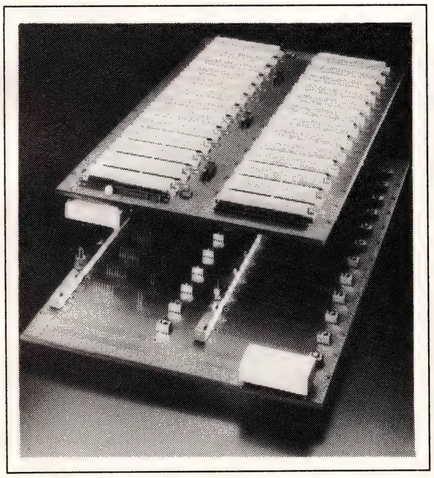
MADE IN AMERICA BY AMERICAN CRAFTSMEN TO AMERICAN STANDARDS OF EXCELLENCE

CIRCLE NO. 16

FDDI (Fiber Distributed Data Interface) compliance and have an 18-dB loss when working with a 50/125 µm fiber. The transmitter converts serial ECL signals to lightwaves in the 1300-nm band at data rates of dc to 220M bps. Operating with either V_{CC} or V_{EE} grounded, the transmitter can directly interface with ECL, pseudo-ECL, TTL, or CMOS inputs. The receiver outputs serial, 5V-referenced ECL signals at rates of 1M to 170M bps. The pair can transmit data over a 5-km range. Both modules operate from a 5V supply. Power consumption equals 60 and 400 mW for the transmitter and receiver, respectively. $475/pair (100).

BT&D Technologies, 2 Righter Pkwy, Wilmington, DE 19803. Phone (302) 479-0300.

Circle No. 380



VXIbus Backplanes

- *Feature onboard protection circuitry*
- *Available with 13 slots*

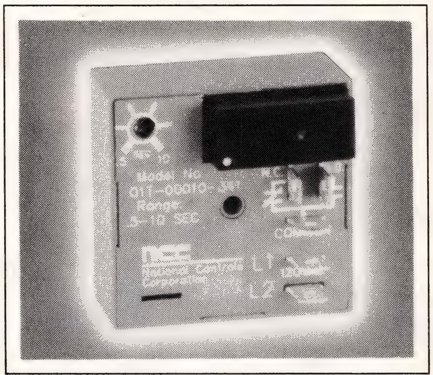
These VXIbus backplanes feature 10-layer stripline construction, which precisely controls characteristic impedance. The backplanes conform fully to ANSI/IEEE 1014-1987, revision 1.3. C and D versions are available in slot configurations ranging from five to 13. All backplanes are provided with six iN4004 diodes to implement the necessary protection circuitry for the analog summing bus. A plug-in active-protection module is available as an alternative. $600 to $2500. Delivery, stock to six weeks ARO.

Bicc-Vero Electronics Inc, 1000 Sherman Ave, Hamden, CT 06514. Phone (203) 288-8001. FAX 203-287-0062. **Circle No. 381**

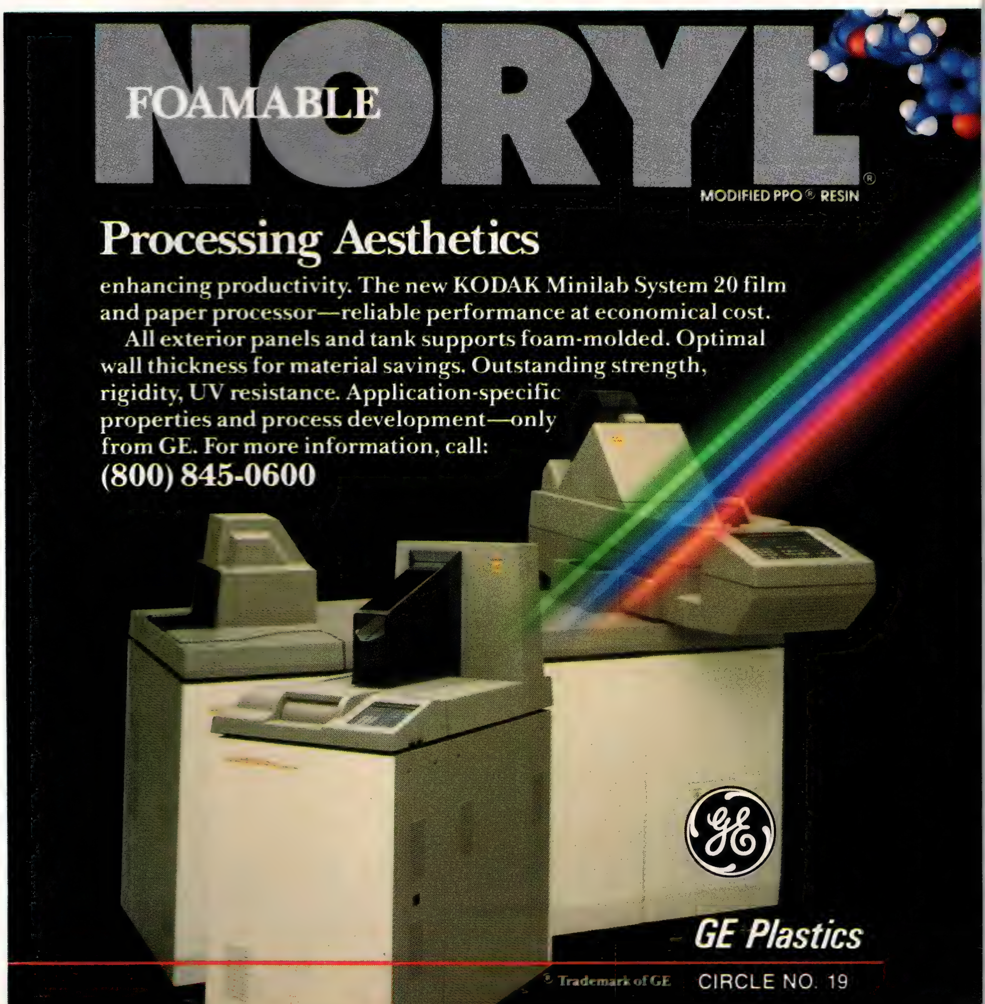
Time-Delay Relays

- *Handle 8A loads*
- *Feature 10-hour delays*

The nine models in the Q1T Series offer time delays ranging from 50 msec to 10 hours. A time-delay adjustment and transient protection are onboard features. A built-in, sealed spdt electromechanical relay will handle resistive loads of 8A and inductive loads of 6A. The relays feature delay-on-make timing logic so the delay starts when the 120V ac input is applied. Electrical life equals 100,000 cycles min. The units are encapsulated in a fire-retardant, solvent-resistant polyester thermoplastic package. They are UL recognized and CSA certified. From $14.25 (100).



National Controls Corp, 1725 Western Dr, West Chicago, IL 60185. Phone (708) 231-5900. FAX (708) 231-1377. **Circle No. 382**


FOAMABLE NORYL®
MODIFIED PPO® RESIN

Processing Aesthetics

enhancing productivity. The new KODAK Minilab System 20 film and paper processor—reliable performance at economical cost.

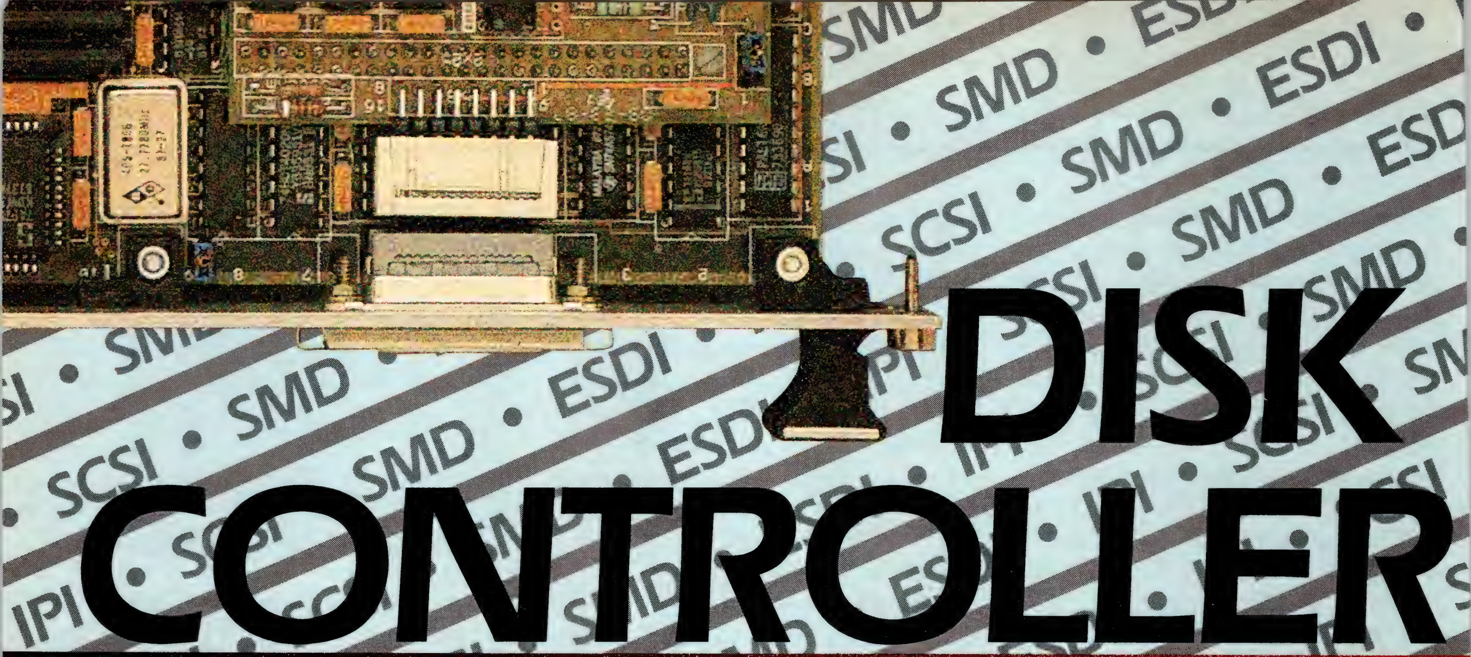
All exterior panels and tank supports foam-molded. Optimal wall thickness for material savings. Outstanding strength, rigidity, UV resistance. Application-specific properties and process development—only from GE. For more information, call:

(800) 845-0600

GE Plastics

® Trademark of GE

CIRCLE NO. 19



DISK CONTROLLER SOLUTIONS

MAKING A CHOICE

System designers usually make two major choices when selecting peripheral controllers: choosing the appropriate technology, and choosing the best supplier of that technology. Interphase is the one choice that's right for both.

A CHOICE SELECTION

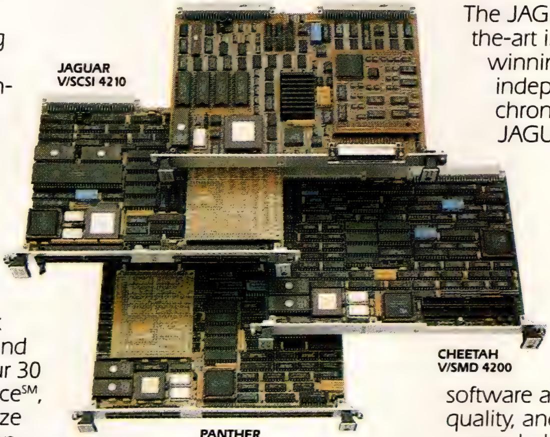
Whether your system calls for IPI, SMD, ESDI or SCSI, Interphase provides not only the highest performing controllers, but a proven approach to design support, on-time delivery, technical service and unrelenting quality. All this has made Interphase the supplier of choice by more OEMs than any other in the industry.

A GREAT CHOICE

There are many reasons why Interphase is a great choice. Our technology squeezes the last ounce of performance out of the disk drive with industry-leading caching and queuing techniques. The speed of our 30 plus MB/s VMEbus BUSpacket Interface℠, the industry's fastest, lets you maximize system performance. We actually listen to what you need, rather than just tell you what we've got. You can rely on us to help you get your system up and running, no matter what. You can count on the highest product quality and best on-time delivery in the industry.

IPI SOLUTIONS

If you're looking for the fastest disk possible, you're probably considering IPI. Our COUGAR V/IPI 4260 is the highest performance open system disk controller available today. Using a full 32-bit 68020 architecture, the COUGAR features our proprietary IPI front-end processor in combination with the exclusive Virtual Buffer Architecture℠ and VMEbus BUSpacket Interface operating at 38 MB/s.



ESDI AND SMD SOLUTIONS

The PANTHER V/ESDI 4201 and CHEETAH V/SMD 4200 are the most designed-in VMEbus disk controllers in the industry. They are still the fastest anywhere, featuring leading edge caching algorithms, command queuing techniques and our BUSpacket Interface – **any** disk drive, **any** speed!

SCSI SOLUTIONS

The JAGUAR V/SCSI 4210 established the state-of-the-art in high-performance SCSI applications – winning every benchmark in sight. With two independent SCSI ports, asynchronous or synchronous, single-ended or differential, the JAGUAR SCSI host adapter can keep all your SCSI devices busy, even including arrays of high-performance drives in file striping or data base applications. Of course the BUSpacket Interface is part of the package.

NO OTHER CHOICE

Regardless of the disk technology you choose for your system – if you want the highest performing products, the best software and technical support, the most reliable quality, and the strongest and most responsive company behind the product – you want Interphase. Since you know which vendor is the best, whether it's disk controllers, Ethernet or FDDI, all you need to do is pick the technology. To help with that choice, we've prepared a booklet comparing disk technologies. To receive a free copy, just call:

(214) 919-9000

INTERPHASE
CORPORATION

OPEN SYSTEMS CONTROLLERS™
Disk • Tape • Networking

13800 Senlac Drive • Dallas, Texas 75234 • (214) 919-9000 • FAX: (214) 919-9200 • NASDAQ-NMS: INPH
Interphase International
Astral House, Granville Way • Bicester, Oxon 0X6 0JT • (01144) 869-321222 • FAX: (01144) 869-247720

Interphase is a registered trademark of Interphase Corporation. Open Systems Controllers is a trademark of Interphase Corporation. Virtual Buffer Architecture and BUSpacket Interface are service marks of Interphase Corporation.

CIRCLE NO. 110

DEVELOPING CHANGE

Capture Dynamic Design, Material And Processing Creativity With GE

Solutions in total from a single source. Diverse material technologies. Copolymers, alloys, composites. Leading-edge process development. In-depth, worldwide market expertise. The exclusive Engineering Design Database—unique design and analysis tools in a total system for plastics engineering.

The innovative KODAK Minilab System 20. Blow-molded developer tanks, injection-molded racks, foam-molded panels and tank supports of NORYL® resin. Rollers of extruded LEXAN® resin.

Unmatched customer commitment, unlimited creative resources—only from GE.

For more information, call:

(800) 845-0600

CIRCLE NO. 20

GE

GE Plastics

® Registered Trademarks of General Electric Company

NEW PRODUCTS

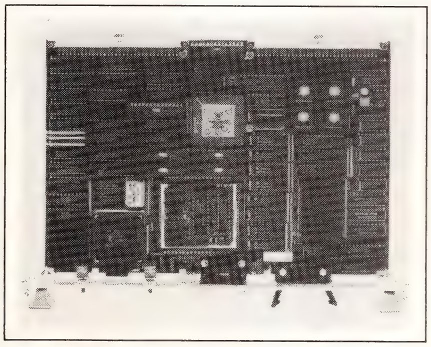
COMPUTERS & PERIPHERALS

Flat-Screen Color Monitor

- *Has from 1024 × 768 to 1600 × 1280-pixel resolution*
- *Automatically adjusts from 48-to 98-kHz scan rates*

The C21L 21-in. flat-screen monitor displays as many as 2 million pixels. The monitor has a display resolution ranging from 1024 × 768 to 1600 × 1280 pixels. The noninterlaced resolution automatically adjusts to horizontal scan rates ranging from 48 to 96 kHz and vertical frame rates from 60 to 80 Hz. Ergonomic features include an adjustable tilt-swivel base and 40-fL brightness, which helps reduce eye strain. The monitor accepts ECL digital input signals through a 25-pin subminiature D-connector or analog inputs through a 9-pin subminiature D-connector. The CRT has 0.31-mm dot pitch and P22 phosphor. The monitor has a video bandwidth of 200 MHz and offers an option as high as 300 MHz. $3895.

Image Systems Corp, 11543 K-Tel Dr, Hopkins, MN 55343. Phone (612) 935-1171. FAX 612-935-1386. **Circle No. 351**



VMEbus Token-Ring LAN Adapter

- *Suits 4M- or 16M-bps networks*
- *Twin 38.4k-bps RS-232C channels*

The CC140 VMEbus module links VMEbus systems to both 4M- and 16M-bps token-ring LANs. The subsystem executes instructions and accesses the VMEbus and peripherals while transferring data frames over the ring. Local data is held in 1M byte of 32-bit-wide dynamic RAM; an additional 512k bytes is dedicated to LAN use via the DMA. In the optional CC140-4 module, this capacity increases to 2M and 4M bytes. The module acts as a VMEbus master or slave and accesses the full 4G bytes of address space. The 4M bytes of 32-bit-wide EPROM contains start-up data and diagnostic and protocol firmware with 2k bytes of EEPROM available for user-defined start-up coding. The module also incorporates a watchdog timer, a 16-bit timer/counter, and two 38.4k-bps RS-232C interfaces. $7350.

Compcontrol BV, Stratumsedijk 31, Box 193, 5600 AD, Eindhoven, The Netherlands. Phone 40 124955. FAX 40 120296. **Circle No. 352**

VMEbus CPU Board

- *Base price comparable to ISA bus CPU boards*
- *Uses either an 8-MHz 68000 or a 10-MHz 68010 μP*

The TSVME 110 VMEbus single-board computer (SBC) has a base price comparable to ISA bus SBCs. A modular design provides for the addition of options. The standard minimum configuration includes an 8-MHz 68000, an 8-MHz 68HC000, or a 10-MHz 68010 μP; four banks of two JEDEC sockets for EPROM, EEPROM, and RAM; two synchronous or asynchronous serial ports; three 16-bit timers; a custom VLSI chip for board-control logic circuitry; a watchdog timer; a real-time clock; and 70- and 12-pin expansion connectors. Options include a Western Digital 37C65 floppy-disk controller; a SCSI port; dynamic RAM ranging from 512k to 2M bytes; a rechargeable or lithium cell; and a P2 Connector. TSVME 110-1 with 64k bytes of static RAM, $589; TSVME 110-2 with 128k bytes of static RAM, 1M byte of dynamic RAM, a SCSI port, a floppy-disk controller, and a real-time clock, $1353 (100).

Themis Computer, 6681 Owens Dr, Pleasanton, CA 94588. Phone (415) 734-0870. FAX 415-734-0873. **Circle No. 353**

Digital Audio Board

- *Records and plays back data on two audio channels*
- *You can program the board to sample from 6.25 to 50 kHz*

The Series 2/Model SX-10 digital audio board for 16-bit ISA bus computers can record and play back data on two separate audio channels. The user can program the board to sample from 6.25 to 50 kHz with 16-bit resolution. Its audio bandwidth spans the 20-Hz to 20-kHz range. The board lets you digitize stereo sound and store the data on a hard disk or CD-ROM. It incorporates a 25-MHz TMS 320C10 DSP chip, which provides 4:1 data compression using adaptive differential pulse-code modulation. A digital interface lets you connect the board directly to a compact disk or digital audio tape. An optional Series 2 driver lets you perform direct-to-disk recording and playback in a high-level programming language such as QuickBasic, Pascal, Turbo, Pascal, or C Language. The board requires a 1:1 disk controller, a hard-disk drive with an access time of 28 msec or less, and DOS 2.0 or later versions. $1995; optional digital-output board, $450; software driver fee, $750.

Antex Electronics, 16100 S Figueroa St, Gardena, CA 90248. Phone (213) 532-3092. FAX 213-532-8509. **Circle No. 354**

isit us at the Design Engineering
how in Chicago at Booth #1423.

Its vast, electronic nervous system will transmit enormous amounts of information at the speed of light thanks to surface-mountable electronic components constructed of materials from Eastman Performance Plastics, such as the advanced Ektar® Filled Blend PCT Polymer.

Eastman is the only manufacturer of PCT, a material that allows the most efficient and economical manufacture of surface mounted components for vapor phase and infrared reflow-solderable printed circuit boards – the circuit boards of the future.

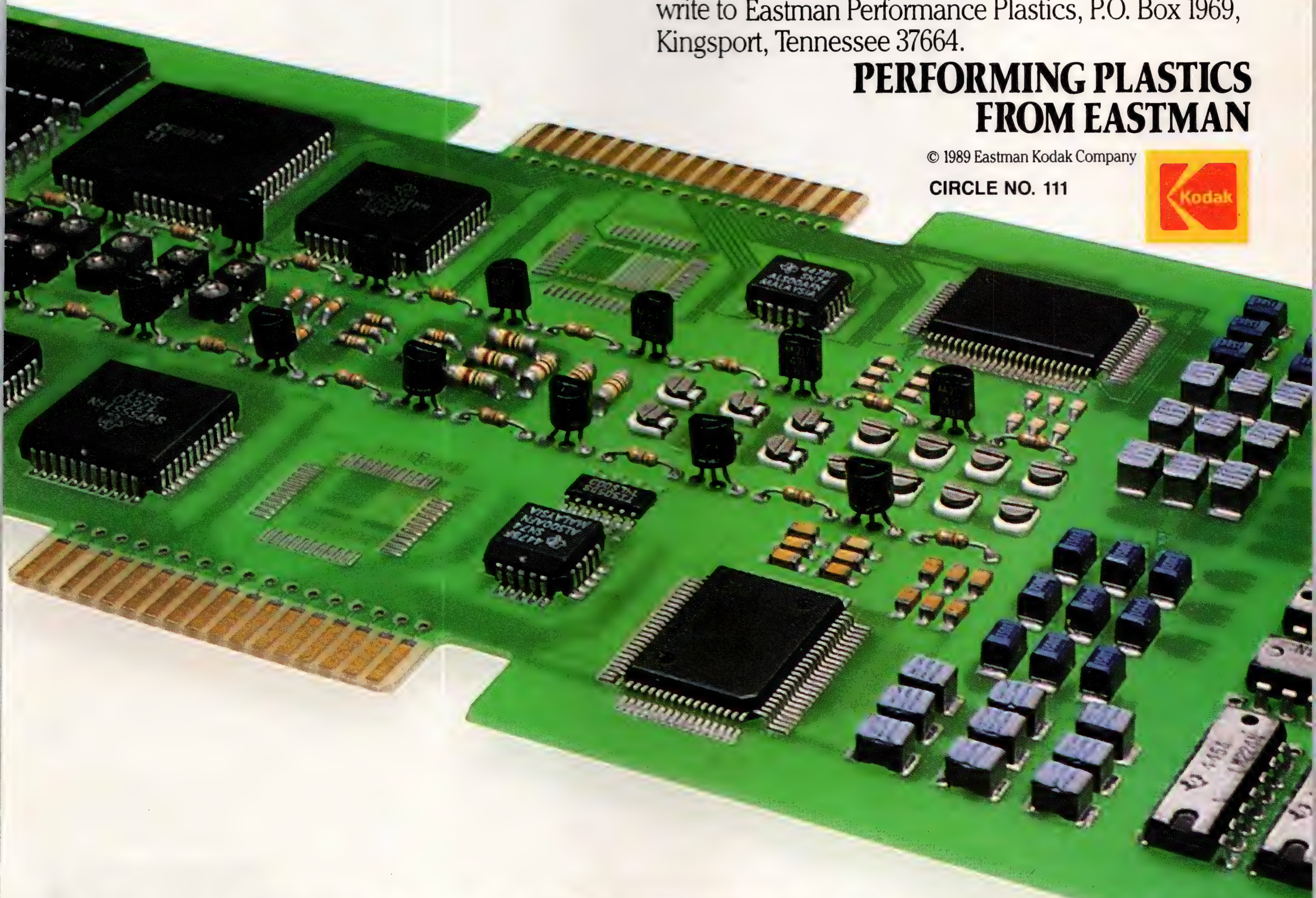
If miniaturization and surface mount technology are driving your need for better performance, greater reliability and increased economy, talk to us about Ektar® FB PCT Polymer and our full range of performing plastics. Call A. Laws at 1-800-EASTMAN or write to Eastman Performance Plastics, P.O. Box 1969, Kingsport, Tennessee 37664.

PERFORMING PLASTICS FROM EASTMAN

© 1989 Eastman Kodak Company

CIRCLE NO. 111

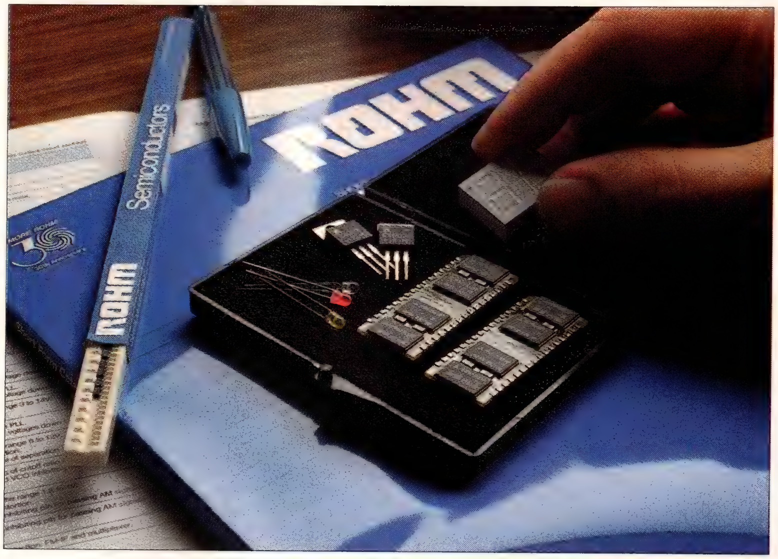
Kodak



THE CITY OF THE FUTURE

® Ektar is a registered trademark of Eastman Kodak Company for its poly (1,4-cyclohexylene dimethylene terephthalate)

Real help.

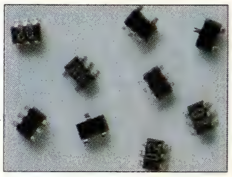


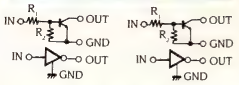
When you're looking for solutions that work *today,* call us. We have products that'll give you some real help.

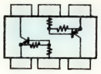
See, we're a lot like you. Working hard–often late into the night–to make reliable products that meet real needs.

ROHM makes a great line of components–monolithic and hybrid ICs, LEDs, displays, LCDs, discretes, passives, printheads and more. In fact, we're among the world's top 25 semiconductor companies.

Dual Digital Transistors



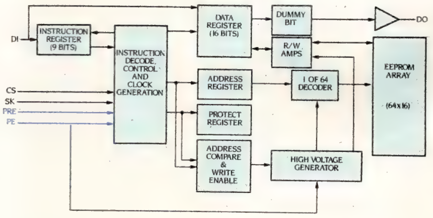




Take our digital transistor series. These combine up to four resistors and two transistors in a SOT-36–a neat little package we developed so we could put more stuff into the same space as the good old SOT-23. And save you a lot of real estate on the circuit board.

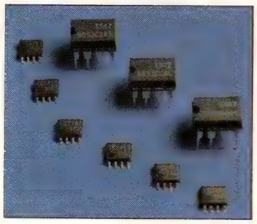
You can get V_{ce} ratings from 11 to 120 volts, and current ranges from 30 to 100 mA. Whichever configuration you choose, they're all the same size, which sure helps simplify your layout. And their surface-mount packaging makes them popular with the manufacturing folks, too.

If you want to know more, call Lynn Briley, shown in the photo below. (The one with the wide part in his hair.) If Lynn's not in, talk to Sharon Whitmore. She's pictured, too. Either one will have answers for your transistor questions.



E^2PROMs

Maybe you need a PROM with low power consumption and high reprogrammability. If so, take a look at our new CMOS 1024-bit EEPROM, the best alternative to traditional NMOS we know of.



In addition to all the standard features you'd expect, the BR93CS46 operates at a low 2.7 volts, drawing only 20 µA. And you can even run it at a full 1 MHz.

The BR93CS46 gives you external read/write memory in sixty-four 16-bit registers, and interfaces with standard microprocessors like Intel's 8048/49/51/96, National's COP4XX, Motorola's 6801/05, TI's TMS1000, and Zilog's Z8. Seven 9-bit instructions control everything.

For more details, call Warren Schoals, the studious guy standing in the back. (Warren's also known as Mr. Whiteshirt when he's not out in his pick-up.)

Next time you're trying to figure out a solution that works today–or tonight–FAX us an S.O.S. Thank-you.

Then turn off the light and go home. Your family will thank you, too.

ROHM

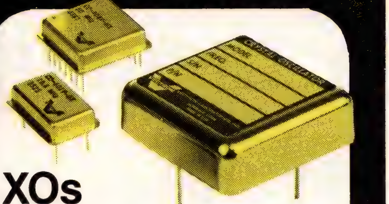
ROHM Corporation ■ 8 Whatney ■ Irvine, CA 92718 ■ (714) 855-2131 ■ FAX (714) 855-1669

CIRCLE NO. 118

©Copyright 1990, ROHM Corporation.

Your One-Stop Source for...

CLOCK OSCILLATORS and VCXOs

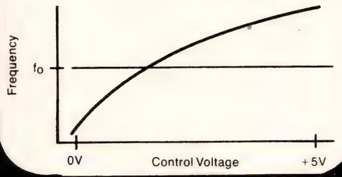


XOs

Logic	TTL:	16 kHz- 100 MHz
	CMOS:	1 Hz- 15 MHz
	HCMOS:	1 Hz- 125 MHz
	*ECL:	5 MHz- 600 MHz
	SINE:	5 MHz-1200 MHz
	*10K, 10KH, 100K, MECLIII & ECLiPS	
Accuracy (at 25°C)	±10, 15, 25 or 50 ppm (±1 ppm optional on some models)	
Stability Standard	±25 ppm over 0/+70°C	
Optional	±50 ppm over −55/+125°C	
Optional	± 5 ppm over 0/+50°C	

VCXOs

Frequency:	TTL:	32 kHz- 70 MHz
	HCMOS:	1 kHz- 70 MHz
	ECL:	8 MHz-200 MHz
	SINE:	8 MHz-600 MHz
Deviation:	±30 ppm to ±200 ppm	
Stability:	±10 ppm over 0/+50°C ±50 ppm over −55/+85°C	

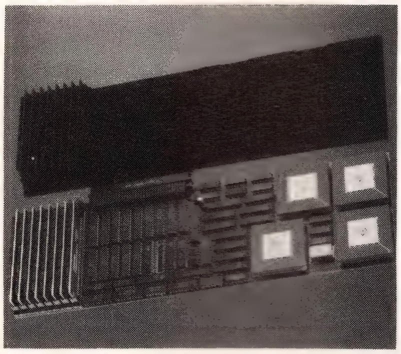


VECTRON

The Crystal Oscillator Company

VECTRON LABORATORIES, INC.
166 Glover Avenue, Norwalk, CT 06850.
Phone: (203) 853-4433. FAX: (203) 849-1423.

CIRCLE NO. 21



RISC Coprocessor Board

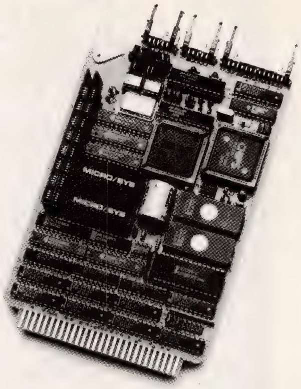
- *Uses Motorola's 88000 μP*
- *Has 2M-byte DRAM and 32k-byte cache memory*

The RP88B25 RISC coprocessor board for the Macintosh II computer uses a 25-MHz 88000 RISC μP that delivers 9M flops and 21 MIPS. The basic configuration includes 2M bytes of dynamic RAM (DRAM) and a 32k-byte cache memory. According to the company, software applications run as much as 37 times faster than standard Mac II 68020-based configurations. A complete set of software development tools in either C or Fortran is available. The RP88KC Base C Kit includes an ANSI standard C compiler, assembler, linker library manager, symbolic debugger, and interface libraries. The RP88KF Fortran Kit requires the Base C Kit and includes an ANSI standard Fortran compiler and libraries. RP88B25 basic configuration, $10,995; upgraded version, including 8M bytes of DRAM, $1500; upgraded version with 32M bytes of DRAM, $6500; optional 16k bytes of cache memory, $500; RP88KC Base C Programmers Tool Kit, $995; RP88KF Fortran compiler and libraries, $1995; RP88P25 development package, including the RP88B25 and Base C Programmer Tool Kit, $13,495.

Tektronix Inc, Box 500, MS 50-662, Beaverton, OR 97077. Phone (800) 835-9433, ext 8800.

Circle No. 355

STD BUS 80C186



with RUN.EXE™

THE CARD . . .
A high-performance computer on a single STD card. 10 MHz CPU, 512K 16-bit wide RAM, 384K EPROM, COM1, COM2, LPT1, clock/calendar, watchdog. Operates in both STDMG standard transfer modes: 8-bit and 16-bit.

THE FIRMWARE . . .
Our popular RUN.EXE firmware lets you use your favorite PC language compiler and libraries. Then copy the .EXE file byte-for-byte into an EPROM and plug it in. Our "Implied AUTOEXEC.BAT" loads and runs your program on powerup.

THE SAVINGS . . .
At $395 in OEM quantity, the SB8186 doesn't blow your budget. RUN.EXE saves memory and DOS royalty money, while its companion PC/XBUG debugger saves development time.

THE FAMILY . . .
Don't need 16-bits and 896K memory? V20 RUN.EXE systems start at $285 in quantity. Call today for details on the SB8186 and other RUN.EXE family members.

MICRO/SYS
1011 Grand Central Ave.
Glendale, CA 91201
(818) 244-4600

RUN.EXE™ trademark MICRO/SYS, Inc.

CIRCLE NO. 23

Because you're thinking fast...

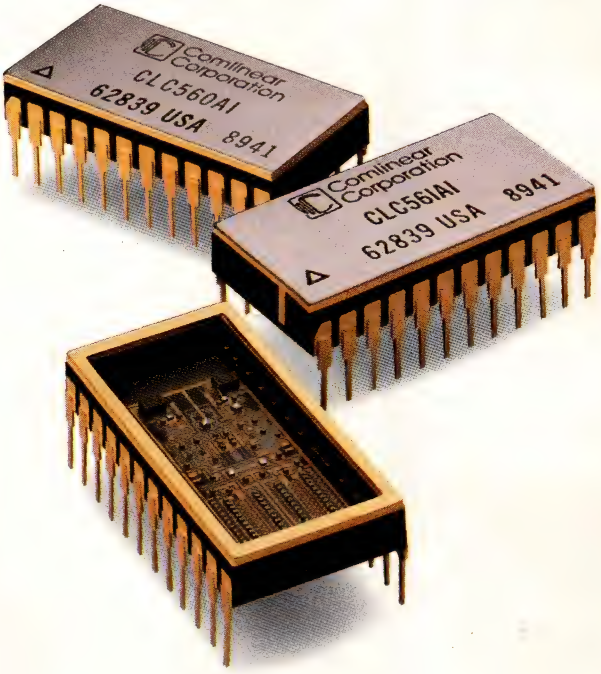
you need responsive suppliers as well as fast parts. Comlinear is tuned in. With high quality, high-speed products. Assistance from R&D-level applications engineers to help develop your ideas quicker. Off-the-shelf MIL-STD-883 compliant monolithics and hybrids. Quality product documentation with guaranteed specs so you don't waste time. In your business, time is everything. Count on us for the speed you need.

Introducing the DriveR-*amps*™... power them up and drive away.

Now, you have alternatives to in-house driver-amplifier designs. Because Comlinear is announcing the first two in a class of off-the-shelf DriveR-*amps*.

You've never seen amplifiers like these before. With high drive they handle difficult loads at high speed. 2nd and 3rd harmonic distortion are a low -51 and -48dBc (18dBm, 20MHz). Plus, user-defined output resistance eliminates backmatching resistors.

Pick the CLC560, with 10ns settling to 0.1%, for driving in the time-domain... pulse and arbitrary waveform generators, for example. Or the CLC561, with minimum 135MHz large-signal (10V_{pp}) bandwidth, for frequency-domain designs such as sine-wave generators/synthesizers. Both are great A/D drivers. So wherever you're heading, find out how to improve your driving... fast.



Comlinear Corporation
Solutions with speed

4800 Wheaton Drive
Fort Collins, Colorado 80525
(303) 226-0500
Fax (303) 226-0564

©1990 Comlinear Corporation

For more information, contact the representative in your area.

Belgium
Tekelec Airtronic
02-360.12.88

France
Micro Puissance
1-69.07.12.11

Ireland
Joseph Electronics, Ltd.
44-21-643-6999

Israel
Elul Technologies
3-264161

Italy
MicroElit S.P.A.
02-4817900

Netherlands
Tekelec Airtronic
079-310100

Spain
Anatronic, S.A.
91-5424455

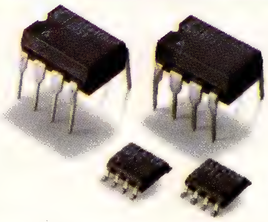
Switzerland
Transtech
Hochfrequenz AG
56-27 18 93

United Kingdom
Joseph
Electronics, Ltd.
021-643-6999

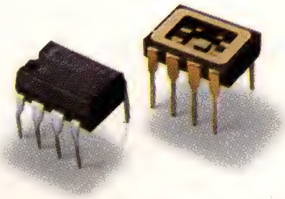
West Germany
Transtech
Hochfrequenz GMBH
089-843017

CIRCLE NO. 126

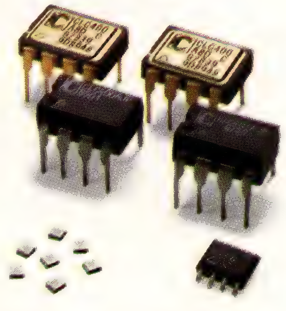
And get a view of these fast op amps...



High-speed video op amp with disable.
The new 200MHz CLC410, with a 200ns disable function, has differential gain/phase specs of 0.01%/0.01°. Power consumption is 160mW on, 40mW disabled. Ideal for video switching/distribution and low-power applications.
CIRCLE NO. 25



Fast 12-bit clamping amp.
For A/D and D/A converter designs, the CLC502 settles to 0.01% in 18ns. It has output clamping to protect sensitive loads. Plus fast overload recovery so overdrive signals don't mask important information.
CIRCLE NO. 26



150/200MHz, 10ns settling, low cost.
Our 200MHz low-gain and our 150MHZ high-gain op amps offer high performance at low cost. Both the CLC400 and 401 have 10ns settling to 0.1%. Versions are available in MIL-STD-883, PDIP, SO-8, industrial ceramic and die.
CIRCLE NO. 27

LITERATURE

Guide to software

The application note entitled *The Guide to 647180X Applications Development* describes microcontroller-based products. The document provides practical 647180X application information along with examples and suggestions. Among the topics discussed are use of the memory manager, processor modes, internal I/O device and memory, upgrade paths, and selecting development tools.

Softaid Inc, 8930 Route 108, Columbia, MD 21045. **Circle No. 383**

How to prevent catastrophic failures

The company's 8-pg brochure describes the effect of power-line disturbances on a data center; it also shows how the Dran-Scan system's central terminal helps prevent catastrophic failures.

Dranetz Technologies Inc, Box 4019, Edison, NJ 08818.
Circle No. 384

Catalog highlights instrumentation products

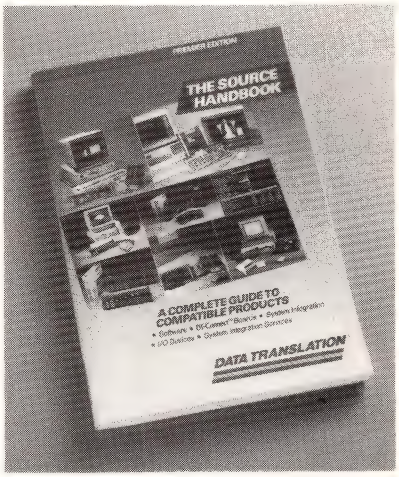
The company's 1990 Catalog describes its comprehensive line of hardware and software products for engineering and scientific applications. The new product section features product updates since April 1989. The four major color-coded sections include application software, IEEE-488 interfaces, data-acquisition products, and VXIbus products.

National Instruments, 6504 Bridge Point Pkwy, Austin, TX 78730. **Circle No. 385**

How to use switching regulators in power supply

Using switching regulators in power-supply and other kinds of circuit design is the subject of *AN30: Switching Regulator Circuit Collection*. The application note provides schematics for more than 80 designs for battery-based switching-power supplies; positive boost, buck, buck-boost, isolated flyback, forward, and high-voltage converters; multi-output regulators and converters; off-line switching regulators; pre-regulators; and dc/dc converters for general-purpose and telecommunications applications.

Linear Technology Corp, 1630 McCarthy Blvd, Milpitas, CA 95035. **Circle No. 386**



Handbook catalogs compatible products

The Source Handbook comprises a 140-pg directory of products and services that are compatible with the vendor's data-acquisition, image-processing, and array-processing products. The publication can save development time and expense by putting users in direct contact with the developers of compatible products. The catalog presents more than 50 manufacturers and software developers. Cross-referenced tables, technical descriptions, and phone listings help you in your selection of products.

Data Translation, 100 Locke Dr, Marlborough, MA 01752.
Circle No. 387

ELECTRO: It's Revolutionary!

It's not just a components show, it's much more!

What distinguishes ELECTRO and sets it apart from all other conferences on the East Coast?

The breadth and depth of the many segments of the electronics industry gathered in one forum, at one time with the newest and most advanced electronics products and technologies. Only ELECTRO successfully integrates product presentations and updates on the current state of technology into a multidisciplinary concurrent engineering framework.

When you come to ELECTRO, it's like attending several vertical shows at once. Nowhere else can you see what's new in components, instruments, EDA tools, power supplies, production materials, engineering services and more at one industry event. No other conference offers you the wide variety of learning opportunities available at ELECTRO.

This revolutionary approach makes ELECTRO your best learning value and the one event YOU CANNOT MISS in 1990. Don't be left behind.

▲ More than 5,000 products being demonstrated by experts knowledgeable in their uses and applications

▲ More than 800 vendors

▲ 51 educational idea-generating tutorials and technical sessions organized in the following tracks: • Marketing • Devices • Electronic CAx • Mechanical CAx • CASE • Manufacturing CAx • Test • Quality • Education • General

▲ Keynote address by Thomas H. Bruggere, chairman of the board and chief executive officer of Mentor Graphics Corp.

▲ Purchasing conference on "Purchasing's Role in Corporate Success" with Frank Tahmoush, Polaroid Corp., and Robert Nahabit, Nahabit Associates

Electro®/90

The Boston T.E.A. Party

May 9-10-11, 1990

John B. Hynes Veterans Memorial Convention Center
and Bayside Exposition Center in Boston, Mass.

For FREE registration and more information, call 213/215-EXPO

Sponsored by Region 1, CNEC and METSAC, IEEE and New England and New York Chapters, ERA

EDN
PRODUCT MART

This advertising is for new and current products.

Please circle Reader Service number for additional information from manufacturers.

SEE US AT MOTION EXPO '90 Boston, MA

MOTIONS NEXT GENERATION

SMC-24 *16 MILLION STEPS*

- Silk Smooth Acceleration
- Speeds Over 23,000 Steps Per Second
- Index to 16 Million Steps
- MIKROSTEP® Control
- Encoder Interface
- Evaluation Board Available/EVB-24

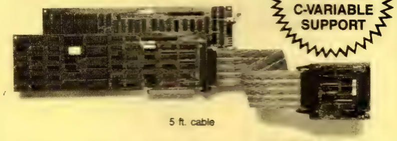
Motion Control/Vision Systems®

ADVANCED MICRO SYSTEMS, INC.
Hudson, NH 03051-4920 1-800-234-2001 ext. 254

CIRCLE NO 325

☆☆☆☆
"The Best 8051 Emulator"

NEW COMPLETE C-VARIABLE SUPPORT



8051

SEE EEM 89/90 Pages D 1324-1326

PC based emulators for the 8051 family

(8051/51FA/31/32/44/152/451/535/552/83C751 + CMOS + more . . .

- PC plug-in boards or RS-232 box.
- Up to 20 MHz real-time emulation
- Full Source-level Debugger including *complete* C-variable support.
- 48 bit wide, 16K deep trace, with "source line trace"
- "Bond-out" pods for 8051, 83C552, 83C451, 83C652, 83C751, 80C515/80C517

Prices: 32K Emulator 8031 $1790;* 4K Trace $1495*

CALL OR WRITE FOR FREE DEMO DISK!
Ask about our demo VIDEO *US only

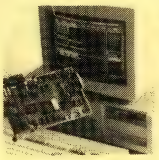
nohau
CORPORATION

51 E. Campbell Avenue
Campbell, CA 95008
FAX (408) 378-7869
(408) 866-1820

CIRCLE NO 326

dRiMotion™ PC DRIVEN MOTION CONTROLLER

$499*



The MP2 2-axis programmable motion controller with sensor support and on-board 3A drivers, provides all necessary functions for closed-loop control of DC motors using the HCTL1000.

An on-board 68HC11 μC and 32k SRAM provides autonomous control independent of the host computer by storing and executing motion sequences.

The MP2 provides five modes of control: Position control, Position motion-sensor profile, Trapezoidal velocity Profile control, Proportional velocity control, and Integral velocity control. Each motion control card includes "C" language basic motion functions library and the "dRiM" controller program.

- Available as a stand-alone control card, or a complete packaged unit. Custom controllers are also available.
- Available 8/16 Amps BRUSH/BRUSHLESS motor drivers.
- 30 day money back guarantee
- FREE dRiM DEMO package 1-800-356-DRIM

Dallas Robotics Corporation
1500 E. Beltline Rd., #100, Carrollton, Texas 75006
Tel. (214) 446-2643, Fax (214) 245-1005

CIRCLE 341 for CONTROLLERS CIRCLE 785 for MOT. DRIVERS

New Color Touch Control Screen

- Operator interface for computer-controlled machines.
- Local screen storage.
- Powerful firmware eases software development.

FLUKE®

John Fluke Mfg., Co., Inc., P.O. Box C9090 M/S 250C
Everett, WA 98206 Toll Free 1-800-426-0361 © 1988, Fluke

CIRCLE NO 328

GPIB and RS-232C PROGRAMMABLE QUAD ATTENUATOR DC-1 GHz, 0-63, 0-127dB, 1dB STEPS

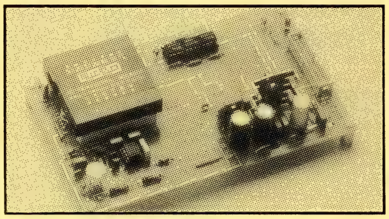
For automated testing and LF through UHF systems, applications, Models 5920/21 feature bus-controlled or stand-alone manual operation. Four independently programmable attenuators share a single GPIB address. $4495/4895, stock to 45 days.

CAL-AV LABS, Inc.
515B Westchester Drive,
Campbell, CA 95008 (408) 371-0666

Since 1959

CIRCLE NO 329

25 BIT A-D CONVERTER



Now, a 25 bit Analog to Digital Converter with Total Microprocessor Control

- 25 Bit Resolution
- Linearity Exceeds 0.0001%
- Temperature Coefficient 0.5 ppm/°C
- True, Continuous Multiple Ramp Integraton
- Adaptor Card with PC Parallel Interface
- Compact Module
- PC Demo Software Included

PREMA®

Precision Electronics, Inc. 4650 Arrow Highway
Bldg. E-5 Montclair, CA 91763-1217
714-621-7292 714-625-2098 (FAX)
800-441-0305

CIRCLE NO 330

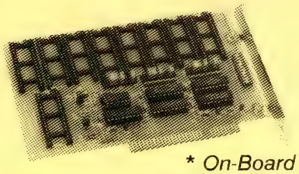
To advertise in Product Mart, call Joanne Dorian, 212/463-6415

Create a DISKLESS PC

IT's EASY..IT's SIMPLE........
THERE's Nothing to it!!!

PROMDISKtm III

IBM PC DISK EMULATOR CARD

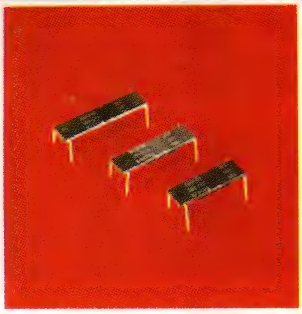


- * *On-Board BIOS ROM*
- * *IBM PC/XT/AT Compatible*
- * *Mix EPROMs, EEROMs, SRAMs*
- * *Emulates up to 1.024Mbyte Drive*
- * *Occupies 32K PC address space*
- * *Supports popular Byte-Wide chips*
- * *Includes PROMDISKtm III Software*

For Information Call or Write:

MICRO COMPUTER SPECIALISTS, INC.
810-208 Los Vallecitos
San Marcos, CA 92069
(619) 744-8087

CIRCLE NO 331

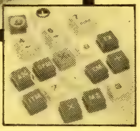


MICRO/Q 2000

FOR A DECOUPLING CAPACITOR THAT SAVES SPACE, DEFEATS NOISE, IS SUITABLE FOR MILITARY APPLICATIONS AND BEATS HUMIDITY, HEAT AND COLD:
ROGERS MICRO/Q® 2000
Rogers Corp., 2400 S. Roosevelt,
Tempe, AZ 85282. 602/967-0624

CIRCLE NO 332

Only a Specialized Manufacturer Could Provide Versatile and Economic Products



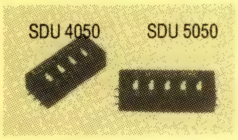
With more than 11 years' experience in this field, we proudly offer you various types of conductive silicone rubber pads, rubber pads with multicolor and screen printing, silicone rubber overlay, rubber pads with screen printing on plastic keytops, 0 rings, washers, inner caps, tubes, etc., and screen printing flexible circuit boards. Please contact us for more information.

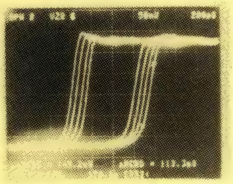
GS
GENERAL SILICONES CO., USA
650 W Duarte 305, Arcadia CA 91006, U.S.A.
Tel: (818) 445-6036. Telex: 3716189 GSCUI.
Fax: 818-4456084

CIRCLE NO 333

ELMEC

ULTRA HIGH-SPEED DIGITAL VARIABLE DELAY LINE





SDU 4050: Step 0, 1, 2, 3, ... 14, 15

Digital/Analog "SDU type" delay line for "GHz." range

	SDU 4050	SDU 5050
Delay Time Variable Range	0~750ps ±5%	0~1.55 ns ±5%
Increment Resolution	50ps, 16 steps	50ps, 32 steps
Rise Time (20%~80%)	150ps or less	200ps or less
-3dB Pass Band	2GHz or more	1GHz or more
Residual Delay Time	350ps or less	400ps or less
IN/OUT Impedance	50Ω ± 10%	50Ω ±10%
Temperature Coefficient	±100 ppm/°C	±100ppm/°C
Outer Dimension (SMD) LxWxH	0.874x0.39x0.26	1.047x 0.39x 0.29

* please refer to our catalog for details.

ELMEC TECHNOLOGY OF AMERICA, INC.
1255 Corporate Center Dr., Suite 406, Monterey Park, CA 91754
phone: (213) 265-1861, FAX: (213) 265-1908

CIRCLE NO 334

---

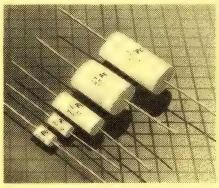
6 800 - Family Development Software

Combine our software and your editor for a powerful development system. Our C-Compilers feature a complete implementation (excluding bit fields) of the language as described by Kernigan & Ritchie and yields 30-70% shorter code than other compilers. Our Motorola-compatible Assemblers feature macros and conditional assembly. Linker and Terminal Emulator are included.

Wintek Corporation
1801 South St., Lafayette, IN 47904
(800) 742-6809 or (317) 742-8428

CIRCLE NO 336

TYPE MWF, AXIAL-FLAT (OVAL) METALLIZED POLYESTER FILM CAPACITORS



- Proven High Reliability
- 100% Burn-In Tested
- 0.1 Mfd. to 18 Mfd.
- 100 WVDC to 630 WVDC
- -55°C to +125°C Min.
- Tolerance: ±10% Std. (±5% Opt.)
- Self-Healing, Extended Foil Windings
- Low ESR, Low ESL Design
- Tape & Reel Available

ic
ILLINOIS CAPACITOR, INC.
3757 West Touhy Avenue
Lincolnwood, IL 60645
(708) 675-1760 FAX (708) 673-2850

CIRCLE NO 337

WANTED

LAS Bug #553201

Setup Time Violation

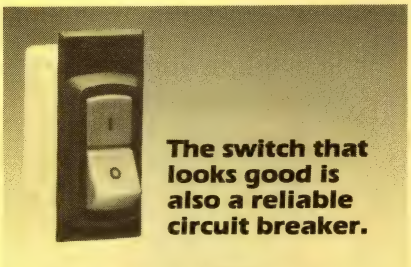
Detect her with the 8 ns resolution the Logic Analysis System

4k to 64k memory depth
16 level triggering with pass counter
40 to 320 channels
A complete Logic Analyzer on a Card
Interactive software under Microsoft™ Windows
Source code in C for automatic testing

BITWISE
DESIGNS, INC.

701 River Street
Troy, NY 12180
(800) 367-5906
(518) 274-0755
FAX (518) 274-0764

CIRCLE NO 338


The switch that looks good is also a reliable circuit breaker.

The dual-function MP 2200 series Rocker Switch/Circuit Protector simplifies and economizes equipment design. Fits attractively on a front panel, in your choice of various color combinations.

Rated for 50,000 on/off cycles. 35X inrush protection, which eliminates nuisance tripping. Double contact break. Five to 25 amps standard rating, others on request.

Write, call or FAX your specifications, or application engineering needs.

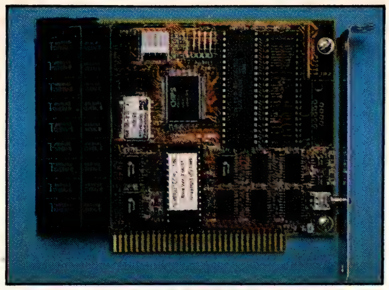
03

1824 River Street
Jackson, MI 49204
P.O. Box 729
(517) 782-0391
FAX (517) 782-2810

MP

CIRCLE NO 339

To advertise in Product Mart, call Joanne Dorian, 212/463-6415



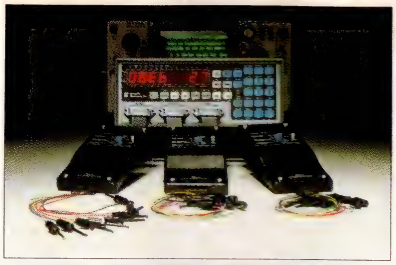
TURBO XT CPU BOARD

- PC BUS, 4.2″ x 5.4″ (4 Layer)
- Compatible with MS-DOS 2.0 - 3.X
- Dual speed (4.77 MHz/10 MHz) CPU
- Up to 2 Meg DRAM on board (SIMMs)
- Includes EMS 4.0 Memory Manager
- Processor: V20 Coprocessor: 8087
- **$320** qty. 1; **$160** qty. 10

295 Airport Road
Naples, FL 33942

1-800-634-0701 **TEMPUSTECH, INC.**

CIRCLE NO 340



LOGIC ANALYZER UNDER $1100

- 20 MHz Acquisition Speed
- 16 Data Channels
- "Search" and "Compare" Routines
- Binary, Hex, Octal, Decimal Data Display
- Timing Diagrams on Oscilloscope
- Synchronous/Asynchronous Analysis
- Optional Personality Pods

Call 1-800-572-1028 for complete information and the name of your local distributor

GLOBAL SPECIALTIES
70 FULTON TERRACE
NEW HAVEN, CT 06512

CIRCLE NO 341

Add Chromafilter windows to optoelectronic displays for color control, contrast enhancement, abrasion resistance, high resolution, and your choice of glare reduction levels. Perfect for LED, LCD, VFD, CRT, plasma, or electroluminescent displays. Order in sheets or as fully fabricated, screen-printed, ready-to-use acrylic or polycarbonate display readout windows. Available in clear, neutral gray, plus a wide variety of colors. Chromafilter. Color control never looked so good! For a free Chromafilter sample, call us today toll free 1-800-222-0618. In New Jersey 1-800-222-0617.

PANELGRAPHIC CORPORATION
10 Henderson Drive, West Caldwell, New Jersey 07006
Phone (201) 227-1500 • FAX (201) 227-7750

CIRCLE NO 342

LOW COST Data Aquisition Cards for PC/XT/AT

12 Bit A/D & D/A [PCL711S] $295

- **A/D converter**: 8 single-ended channels; Uses **AD574** device; Conversion time is less than **25μsec; Input range: ±5V**; Software Trigger Mode only.
- **D/A converter**: 1 channel; 12 bit resolution; 0 to **+5/10V** Output Range.
- **Digital I/O**: 16 In/Out(TTLcompatible); External Wiring Terminal Board incl.
- **Utility Routines** and **Demo/Sample Programs** for **BASIC** and **Quick-BASIC**.

12 Bit A/D & D/A [PCL812] $375

- **A/D converter**: 16 single ended inputs; Uses AD574; Conversion time less than 25μsec; Built-in programmable pacer; Input Ranges: ±10V, ±5V, ±1V.
- **D/A converter**: 2 channels; 12 bit resolution; Output Range 0-5V.
- **Digital I/O**:16In/Out(TTLcompatible); **Programmable Counter/Timer** (8254).
- **DMA** and interrupt capability. Utility software and sample program in BASIC.

Fast 12 Bit A/D/A [PCL718] $895

- **A/D converter**: 16 single ended or 8 differential channels; 12 bits resolution; Programmable scan rate; Built-in Interrupt and DMA control circuitry. Conversion speed **60,000 smpls/sec** (standard), **100,000 smpls/sec** (optional).
- Input Ranges:Bipolar : ±10V, ±5V, ±2.5V, ±1V, ±0.5V; Unipolar:10,5,2,1V
- **D/A converter**: 2 channels; Resolution: **12 bits**; Settling time: **5μsec**; ±5V
- **Digital I/O**:16In/Out(TTLcompatible); **Programmable Counter/Timer** (8254).
- **Software:** Utility software for BASIC & QuickBASIC included. Sample prgm. Supported by **LabDAS, ASSYST, LABTECH, UnkeScope.**

6 Channel 12 bit D/A [PCL726] $495

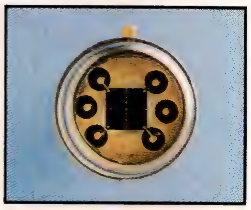
- **Output Ranges**: 0 to +5V, 0 to +10V, ±5V, ±10V, or sink 4-20mA.
- Settling time: **70μS.** Linearity: **±1/2bit.** Voltage output drive capacity: **±5mA.**
- **Digital I/O:** 16 digital input and 16 digital outputs (TTL compatible).

MC / VISA / AMEX *Call today for datasheets!*

B&C MICROSYSTEMS INC.
355 West Olive Ave, Sunnyvale, CA 94086 USA
TEL: (408)730-5511 FAX: (408)730-5521

CIRCLE NO 343

FEATURED PRODUCT OF THE MONTH



CD33H-4D
Quadrant
Silicon
Photodiode

- Low noise
- High sensitivity, low crosstalk
- Hermetically sealed in TO-5 case
- Each element 1.25mm² with 0.05mm separation between elements
- Offered at very competitive pricing

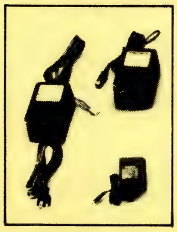
CENTRONIC, INC.
1829 DeHavilland Drive
Newbury Park, CA 91320

Tel: 805-499-5902 **FAX: 805-499-7770**

New Catalog Available Upon Request

CIRCLE NO 344

EXTERNAL POWER SUPPLIES



ALL COUNTRIES CONFIGURATIONS & RATING

- DESK TOP & WALL PLUG-IN
- MULTI & SINGLE VOLTAGE INPUT/OUTPUT
- AC/DC, AC/AC, REGULATED & UNREGULATED
- MULTIPLE SAFETY APPROVALS: UL, CSA, VDE, AUSTRALIA, JAPAN T - MARK, BSI/ASTA, SEMKO, ISRAEL, DEMKO, IMQ, SEV, TUV
- **APPLICATIONS:** APPLIANCES, MEDICAL, COMPUTERS, MODEMS, INDUSTRIAL, INSTRUMENTS, ETC.
- EXTREMELY COMPETITIVE PRICES
- MANY STANDARD MODELS IN STOCK
- CUSTOM UNITS - J.I.T. DELIVERY

TRANSFORMERS • COILS

- Competitively Priced
- JIT & Stock Delivery
- Standard & Custom Models
- PCB & Screw Mounting
- UL,CSA,VDE, Safety Approvals
- 0.2 - 6000 VA

GlobTek, Inc. *Worldwide Approved Electrical & Electronic Components*

7700 Marine Rd. • N. Bergen, N.J. 07047 USA
Tel. (201) 861-0246 • Fax: (201) 861-0740

CIRCLE NO 345

IEEE 488

Easiest to use, GUARANTEED!

- IBM PC, PS/2, Macintosh, HP, Sun, DEC
- IEEE device drivers for DOS, UNIX, Lotus 1-2-3, VMS, XENIX & Macintosh
- Menu or icon-driven acquisition software
- IEEE analyzers, expanders, extenders, buffers
- Analog I/O, digital I/O, RS-232, RS-422, SCSI, modem & Centronics converters to IEEE 488

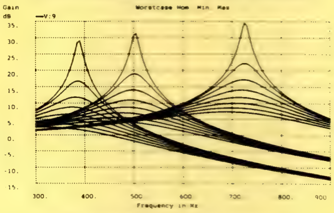
Free Catalog & Demo Disks
(216) 439-4091

IOtech

IOtech • 25971 Cannon Rd. • Cleveland, OH 44146

CIRCLE NO 346

Worstcase at its Best!



Analog Circuit Simulation

ECA-2 Electronic Circuit Analysis offers the best Monte Carlo and Worst-Case analyses with the capability to concurrently plot random samples or Min/Max/Nominal values.

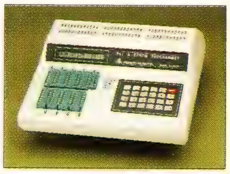
- AC, DC, Transient Fourier, Temperature
- Sine, Pulse, PWL, SFFM, and Exponential generators
- **2 to 50 times faster than SPICE**
- Interactive/batch modes
- Full nonlinear simulator
- Over 500 nodes
- Multiple plots

ECA-2 2.50 IBM PC or Mac **$775**
Call 313-663-8810 for FREE DEMO disk

Tatum Labs, Inc.
3917 Research Park Dr. B-1, Ann Arbor, MI 48108, USA
313-663-8810

CIRCLE NO 347

AR-9820 Gang E/EEPROM plus PLD Programmer w/ FREE UV ERASER



TWO PROGRAMMERS FOR THE PRICE OF ONE!!

FOR ONLY $1495.00 YOU GET:

- 8 Socket gang programmer of E/EEPROMs
- Programs most 20 and 24 pin PLDs
- Stand Alone or Remote Control
- Supports 4 File Formats and 4 Programming Algorithms
- AR-9820 includes: software, cable, 2 free software updates
- FREE UV ERASER
- 30-Day Money Back Guarantee
- Other fine programmers available. As in our AR-9830A, Universal Programmer/IC Tester

1 (800) 654-9838

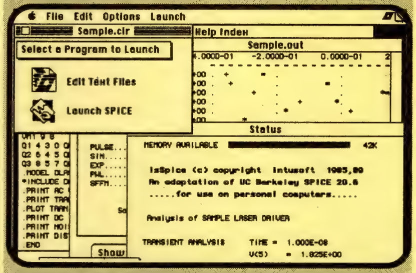
ARI **American Reliance Inc.**
9241 E. Valley Blvd.
Rosemead, CA 91770

CIRCLE NO 348

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

Analog Circuit Simulation

SPICE FOR THE MACINTOSH



```
.0000-01    -2.0000-01    0.0000-01
Q1 4 3 0 0
Q2 6 4 5 0
Q3 8 5 7 0
.MODEL DLA
*INCLUDE D
.PRINT AC
.PRINT TRA
.PLOT TRAN
.PRINT DC
.PRINT NOI
.PRINT DIS
.END
PULSE...
SIM....
EXP....
PWL....
SFFM...
MEMORY AVAILABLE                42K
IsSpice (c) copyright  Intusoft  1985,89
An adaptation of UC Berkeley SPICE 2G.6
.....for use on personal computers.....
Analysis of SAMPLE LASER DRIVER
TRANSIENT ANALYSIS     TIME =  1.000E-08
                       V(5)   =  1.825E+00
```

***intusoft* introduces the NEW !! IsSPICE/MAC,**
The only Spice program to run on all Macintoshes (Plus, SE, SE/30 and Mac II) in as little as 1 megabyte of RAM. The simulatable circuit size is only limited by the amount of RAM. Coprocessor ($210) and Non-coprocessor ($95) versions are available. Also available is **PRESPICE/MAC** ($175) which contains extensive model libraries, the IsSPICE netlist editor and ICAPS, an easy to use menu system especially adapted for the MAC environment.

P.O. Box 6607
San Pedro, CA
90734-6607

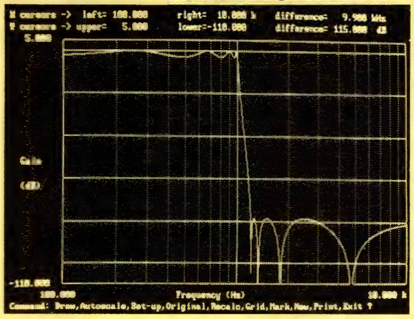
intusoft

(213) 833-0710
30 Day Money
Back Guarantee

Macintosh is a registered trademark of Apple Computer

CIRCLE NO 349

New AFDPLUS
Advanced Active Filter Design Software



```
X cursors -> left= 100.000     right=  10.000 k    difference=   9.900 kHz
Y cursors -> upper=   5.000    lower=-110.000      difference= 115.000  dB
Command: Draw,Autoscale,Set-up,Original,Rescale,Grid,Mark,New,Print,Exit ?
```

- Fully Interactive
- On Screen Design & Evaluation
- On Screen Editing
- Menu Driven
- Automated Installation
- Schematic Display & Print
- Integrated AFDSIM

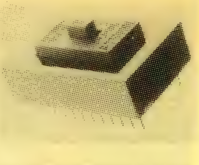
Introductory price $850.00 (price effective through 01/31/90)
Call for your **FREE DEMO DISK** (303)-499-7566 or to order AFDPLUS send check or purchase order to

RLM Research
P.O. Box 3630
Boulder CO 80307-3630

MasterCard ® VISA ®

CIRCLE NO 350

8PDT Breadboard Switch with .100" x .600" Pin-Spacing



For use with plug-in breadboards or wire-wrap prototypes
This "byte-wide" switch speeds circuit development and helps evaluate in-circuit performance of active and passive components by answering "what if...?" in seconds. Also useful for prototyping circuits using the high density (.050" x .200") HDMP-8 series.

HBC-8PT.......... PC Mount........ $18.95
HBC-8WG......... Wire-Wrap...... $22.95

SPECIAL OFFER

Evaluate the power of high density switches in your application with the HDSAM sample kit.

CONTENTS:
1 each HBC 8PT and HBC-8WG breadboard switches
2 each HDMP-8 and HDMP-8P high density switches
2 each HDMP-25 low profile 25PDT high density
1 each HDMP-25M 25PDT switch with large knob
Order part number HDSAM for special price of $99 US funds (price when ordered separately - $130.40 US).

Phone and FAX orders shipped same day, we will invoice against your company purchase order.

ANNULUS
HIGH DENSITY SWITCHES

Annulus Technical Industries, Inc.
1296 Osprey Drive P.O. Box 7407
Ancaster, Ontario, Canada L9G 4G4
Tel (416) 648-8100 FAX 648-8102

CIRCLE NO 751

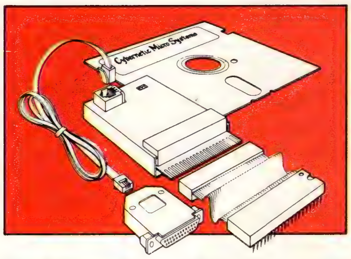
PL/M-51
C-51
support

8051/52
In-Circuit Emulators

- Source level debug for PL/M-51 and C-51
- IBM-PC/XT/AT/386 windowing interface with EGA 43-line, color, and mouse support
- Complex Hardware real-time breakpoints
- Hardware Trace Buffer with filtering control
- Program performance analysis
- 8 level hardware sequencer, Pass Counters
- NO PC PLUG-IN Boards

SIGNUM SYSTEMS
171 East Thousand Oaks Blvd Ste 202
Thousand Oaks, CA 91360
(805) 371-4608 **telex: 362439**

CIRCLE NO 752

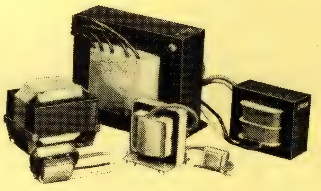


8051 Emulator - $1250

d^{2}ICE is a low cost, Full Speed, real time 8051 Emulator.. Powerful user interface for Hi-level multi-window source code debugging. Uses IBM-PC COM1/2. No Slots! Portable, fits in shirt pocket. Assembler and test bed included.

Cybernetic Micro Systems
Box 3000 • San Gregorio, CA 94074
(415) 726-3000 • Telex: 910-350-5842

CIRCLE NO 753



Transformers as innovative as your designs

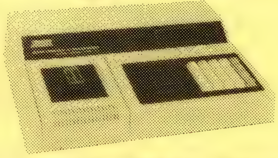
52-page full color catalog provides descriptions, illustrations and complete specifications on thousands of standard off-the-shelf transformers, power supplies, power conversion and AC-DC designs. Also covered is MagneTek Triad's custom design service which has designed and manufactured thousands of custom transformers, from small switches to large ferro-resonant models.

For more information, write MagneTek Triad
1124 E. Franklin St., Huntington, IN 46750
or phone (219) 356-7100.

MagneTek

CIRCLE NO 754

JE680 Universal Programmer



- ***Programs PROMs, EPROMs, EEPROMs, PALs, GALs, RALs, EPLs and PLDs***
- ***Stand-alone or computer controlled modes w/MS-DOS menu-driven software***
- ***JEDEC standard supported***
- ***Parallel and RS232C interface ports***
- ***Optional 40-pin MPU module available***

Listing of programmable devices and 80-page catalog available upon request!

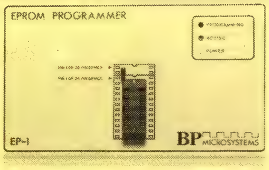
JE680 Universal Programmer............**$1799.95**

Mail Order Electronics - Worldwide
Jameco
ELECTRONICS

1355 Shoreway Road, Belmont CA 94002
Phone (415) 592-8097
FAX (415) 592-2503

CIRCLE NO 755

EPROM PROGRAMMER



- ✔ Programs 2764 in 8 sec, 27512 in 44 sec
- ✔ Reads, copies and programs over 475 E/EPROMS from 35 mfg's including 2716-27513, 27011, 68764, 68766, 2804-28256
- ✔ Automatically uses the fastest recommended algorithm as specified on the manfacturer's data sheets to ensure reliable data storage
- ✔ Connects to RS-232 on any computer, PC, XT, AT, PS/2, Mac, etc.
- ✔ Supports XMODEM/XMODEM CRC protocols & ASCII file xfers
- ✔ Optional microcontroller heads support 874x and 87C51 series
- ✔ Supports Intel, Motorola, straight hex, hex-space & binary files
- ✔ Engr support team for fast updates
- ✔ One-year warranty (parts & labor)
- ✔ Toll-free technical support
- ✔ 30-day money back guarantee
- ✔ 8 baud rates to 38400
- ✔ Checksums supported
- ✔ Gold Textool socket
- ✔ Collates 16- & 32-bit
- ✔ Same day shipment
- ✔ UV erasers from $39.95
- ✔ Thousands of satisified customers attest to the EP-1's great value
- ✔ Low price, **$349**, includes IBM compatible communications program, user's manual and two free update coupons

The Engineer's Programmer

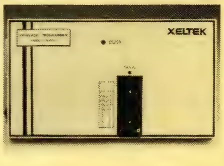
CALL TODAY 800/225-2102

BP MICROSYSTEMS
10681 Haddington, Suite 190, Houston, TX 77043
713/461-9430 FAX 713/461-7413

CIRCLE NO 756

UNIVERSAL PROGRAMMER

@programs
E(E)PROM,
PAL,EPLD,
GAL,PEEL,FPL,
BIPOLAR,
8748/51 SERIES.
@tests **TTL/CMOS**
D/S RAM.



$585 Complete. (u.s.only)

-programs E(E)PROMs upto 2MBits and 16 Bit wide.
-16Bit- and 32Bit- WORD SPLIT & 4-GANG adaptor.
-programs PALs (22V10) from AMD,MMI,TI,NS,SAMSUNG.
-supports PALASM2/CUPL/ABEL/ORCAD JEDEC files.
-supports VERIFICATION using TEST VECTORs.
-programs GALs & FPLs from LATTICE,SGS,NS,SIGNETICS.
-supports RALs in GAL (16V8,20V8) devices.
-programs EPLDs from INTEL,ALTERA,ATMEL,CYPRESS.
-programs PEELs from ICT,HYUNDAI,GOULD(253,273).
-programs BIPOLAR PROMs.
-programs SINGLECHIPs 8748,8751,87C51 SERIES including
-87C451,87C751,63701X/Y/V,63705V with adaptors.
-tests ICs (TTL,CMOS) & MEMORYs (upto 1MB)
-with USER-DEFINABLE TEST PATTERN GENERATION.
-High-Speed,Parallel Interface & S/W Upgradable for New Parts.

XELTEK
473 SAPENA CT. #26
SANTA CLARA,
CA 95054

1-800-541-1975 (Toll Free Order)
TEL: (408) 727-6995
FAX: (408) 727-6996
COD,VISA,MC,AMEX

CIRCLE NO 757

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

PLD designs?

LOG/iC is simply optimal!

Prove it to yourself . . .
Call **(800)** 777-1202
for free evaluation.

LOG/iC

adams·macdonald
CORPORATION

800 Airport Road · Monterey,
CA 93940 · Fax (408) 373-3622
Telex 882141 · Tel. (408) 373-3607

ISDATA

CIRCLE NO 758

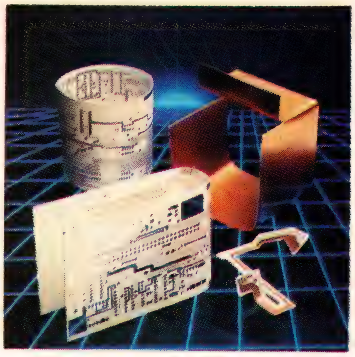
PC BASED UNIVERSAL DEVICE PROGRAMMER $595-845

- Programs **EE/EPROMs, PALs, GALs, IFLs, EPLDs, MICROs, BIPOLARs.**
- Software driven pin drivers. **D/A generated** programming voltages (8 bit DACs used to generate voltages from **5-25V with 0.1V resolution** for all 40 pins)
- **Upgradeable for virtually any future programmable devices up to 40 pins.**
- Self subsistent operation. No additional modules or plug-in adapters required.
- Includes user friendly **MEMORY BUFFER FULL SCREEN EDITOR.** Commands include: Fill, Move, Insert, Delete, Search. ASCII or HEX entry.
- Friendly Menu-Driven interface. **Device selection by P/N and manufacturer.**
- Supports **8/16/32** bit data word formats.
- Programming algorithm:**Normal, Intelligent I&II, Quick Pulse Programming.**
- Verify operation performed at normal & worst case operating voltage
- **Functional test:** JEDEC standard functional testing for logic devices. TTL Logic functional test for 74xx/54xx series devices.
- File formats accepted: **JEDEC (full), JEDEC (kernal), Straight Hex, MOS Technology, Motorola Hex, Intel Hex, Tektronix Hex.**
- Customer support via voice line, fax & dedicated BBS. **Full 1 year warranty.**
- **Base price ($595)** includes Interface card, cable, Memory device library and 1 year free updates.Additional **Device Libraries (Logic, Micros, Bipolars) $95ea.**
- Library updates can be received via floppy or Customer Support BBS.

MC / VISA / AMEX *Call today for datasheets!*

B&C MICROSYSTEMS INC.
355 West Olive Ave, Sunnyvale, CA 94086 USA
TEL:(408)730-5511 FAX: (408)730-5521

CIRCLE NO 759



WE'RE BENDING THE RULES FOR CIRCUIT DESIGNERS

BEND/FLEX™, the bendable board material flexible enough to bend into any multi-plane shape. Eliminates stiffeners, flex-hardboard connectors. May reduce cost of two- and three-plane interconnect systems by as much as 30%!

Rogers Corporation Composite Materials Div.
Rogers, CT 06263. (203) 774-9605.

CIRCLE NO 760

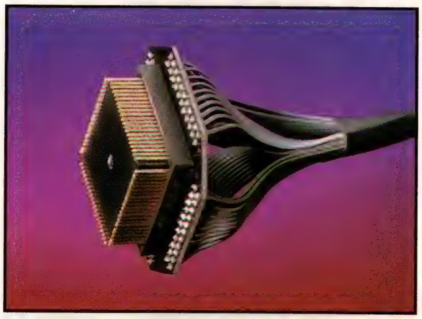
RELIABILITY PREDICTION SOFTWARE

ARE YOUR PRODUCTS RELIABLE?

The RelCalc 2 Software Package predicts the reliability of your system using the part stress procedure of MIL-HDBK-217E, and runs on the IBM PC and full compatibles. Say goodbye to tedious, time consuming, and error prone manual methods! RelCalc 2 is very easy to use, and features menu windows, library functions, global editing for what-if? trials, and clear report formats. Try our Demo Package for $25.

T-CUBED SYSTEMS, 31220 La Baya Drive #110, Westlake Village, CA 91362. (818) 991-0057 • FAX: (818) 991-1281

CIRCLE NO 761



Easy Emulator Pods & Adapters

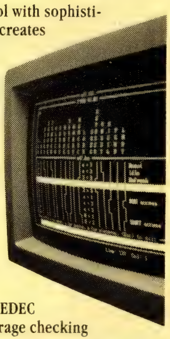
- Plug your PLCC and LCC packages into your PC board in minutes, with these easy-to-use adapters.
- Emulator/logic analyzer users: Adapt-a-Pod™ converts one package type to another (LCC, PLCC, PGA, and DIPs).
- Emulator pods and adapters are available in all standard pin counts, with ribbon or ribbon cable headers.
- Custom engineering services and do-it-yourself emulator pod converters. Free catalog.

Emulation Technology, Inc.
2368-B Walsh Ave. Santa Clara, CA 95051
Phone: 408-982-0660 FAX: 408-982-0664

ET

CIRCLE NO 762

Tango-PLD. The New Price/Performance Leader.



Tango-PLD, a universal PLD design tool with sophisticated features at an affordable price, creates complex designs with multiple PALs and GALs. Our top-down approach, emphasizing logic description first and part selection second, along with a "C-like" design language, makes Tango-PLD easy to use.

Tango™

Describe designs with Boolean equations, truth tables, state machines, high-level C expressions, or existing JEDEC files. Simulation with test-vector coverage checking guarantees no surprises. Rich functionality, one year's updates, free tech support and BBS, plus our 30-day guarantee. All this for **just $495**. Call today.

FREE EVALUATION PACKAGE
800 433-7801 619 554-1000 619 554-1019 Fax

ACCEL™ Technologies ▪ 6825 Flanders Drive ▪ San Diego, CA 92121 USA
International prices may vary. Contact us for the distributor nearest you.

CIRCLE NO 763

8051

PC BASED EMULATORS

- Source Level Debug for PL/M and 'C'
- Source Level trace
- Debug with symbols, not HEX data
- Source Level disassembly with in-line assembler
- Interchangeable probe cards
- Up to 128K emulation memory
- 20 MHz real-time emulation
- Up to 4K trace buffer
- Performance analyzer
- TRUE 8051 Emulation including all I/O ports, idle, power down, DMA, and WatchDog timers at **NO** additional cost
- Breaks set symbolically
- Fully documented
- Serially linked to PC
- OEM supplier to 8051 IC manufacturers
- Unlimited FREE technical support
- From $1495*

MetaLink™...Originators of the PC Based 8051 Emulator

We have more 8051 emulators than anyone in the world: 8031, 8051, 8032, 8052, 8344, 8044, 80C152JA/JB/JC/JD, 83C152JA/JC, 80C452, 80C51FA, 80515, 80535, 80512, 80532, 80513, 80C517, 80C521, 80C541, 80C321, 8053, 8XC154, 8XC451, 8XC552, 8XC562, 8XC652, 8XC751, 8XC752, 80C537, CMOS, EPROMs, OTPs

Call or write for Free demo diskette

1-800-METAICE®

MetaLink® Corporation

NOW 8XC552 & 80C517 SUPPORT

MetaLink Corporation P.O. Box 1329, Chandler, AZ 85244-1329
(602)926-0797 FAX: (602)926-1198 TELEX:4998050 MTLNK
*Price is U.S. list

CIRCLE NO 764

DS-51 CEIBO

8051 EMULATOR $950*

INCLUDED IN THE PURCHASE PRICE

- Real-time and transparent In-Circuit Emulator with 64K breakpoints, 64 KByte Internal Data and 64 KByte Internal Code Memory.
- Personality probe for ROMless versions of 8051 μC (8031-2 - etc).
- User software including symbolic debugger, on line assembler and disassembler, PLM and C support, source and listing windows.
- RS-232 Interface Cable and Power Cord.
- User's Manual and Operating Instructions.

AND OF COURSE THE GREAT OPTIONS !!!

- Trace and Logic Analyzer-32K x 32 - 5 External Testpoints........ $800*
- EPROM Programmer for 27xxx type memories........ $250*
- Personality Probe for 8051 μC with Internal Code........ $500*

For more information call or write to:

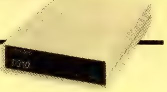
USA:	105 Gleason Rd. Lexington MA 02173	Phone Fax	617-863-9927 617-863-9649
Germany:	Krankenhausstr. 12 D-8870 Günzburg	Phone Fax	(082-21) 30023 (082-21) 30462
Hong Kong:	P.O.Box 30719 Causeway Bay	Phone Fax	(852) 5-454341 (852) 5-8541302
Israel:	P.O.Box 2106 Herzelyia 46120	Phone Fax	(972-52) 555387 (972-52) 559170

* US ONLY

CIRCLE NO 765

Telecom Design!

TELEPHONE/COMPUTER INTERFACE



T-310 Telephone Access Unit with 2-way Touchtone/ASCII conversion:

- **Intelligent dialer** for PCs and other DTE devices. Responds to call progress tones, voice, and other calling signals. ASCII controlled DTMF and audio input.
- **Intelligent answering device** reports incoming rings for auto or commanded answer. Answer tone, audio port, and DTMF to ASCII conversion for remote phone data entry.

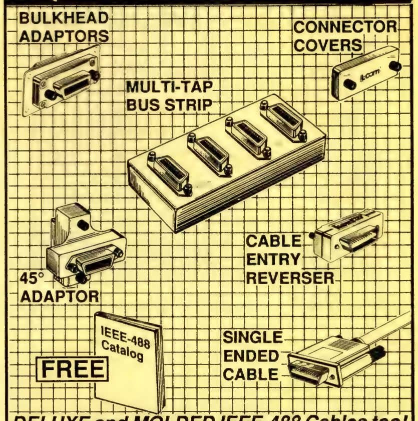
For more info call: **1-800-426-3926**
(In Washington State: 206-827-9626)

TELTONE®
10801-120th Avenue NE, Kirkland, WA 98033

CIRCLE NO 766

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

IEEE-488 USEFUL AIDS



DELUXE and MOLDED IEEE-488 Cables too!

L-com®
1755 Osgood St., N. Andover, MA 01845
Inquiries 508 682-6936 FAX 508 689-9484
Toll Free Ordering **800 343-1455**

CIRCLE NO 767

ZWORLD ENGINEERING

Dynamic C

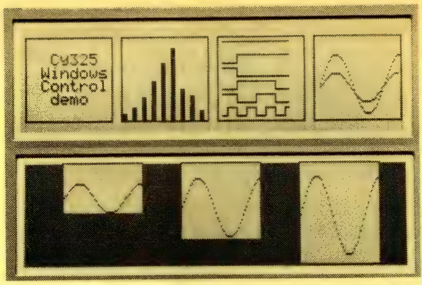
For Real-Time Embedded Systems

Z80/Z180/HD64180

A new idea! An integrated C development environment with editor, compiler and source level debugger. Memory-resident on your host PC. Compiles, while downloading to the target, at 25,000 source lines per minute. Complete, low-priced system includes an IC180 in-circuit emulator and Dynamic C software. *Ask for a* ***Free Demo Disk.***

1340 Covell Blvd. • Davis, CA 95616
(916) 753-3722 • Fax: (916) 753-5141

CIRCLE NO 768



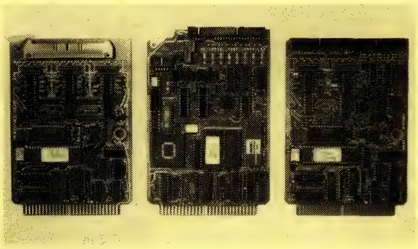
LCD WINDOWS CONTROLLER

The CY325 supports LCDs up to 128x240 pixels (16x40 char) with easy-to-use high-level commands and Parallel or Serial interface to host computer. The 256 built-in windows (or make your own) support window-relative text, graphics, plotting, bargraphs, waveforms, scroll/wrap/clip, etc. Read from an A/D and Write into Window! Separate text and graphic planes can be written or erased in any window. Eight pins support a variety of functions (soft-keys, wavefoms) or can be used for GP I/O. Icons or special fonts can be user defined. Giant character mode, etc. Save months of design time with the CY325. $75 CMOS $20/1000s.

Cybernetic Micro Systems Inc.
P.O. Box 3000 • San Gregorio, CA 94074 • USA
Phone: (415) 726-3000 • Telex: 910-350-5842

CIRCLE NO 769

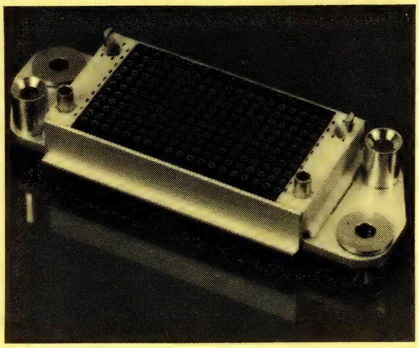
STD ANALOG I/O CARDS



Up to 16 analog inputs and 8 analog outputs w/ 12 bit resolution on one card. Throughput rates from 3 kHz to 59 kHz. TTL or CMOS. Convert on demand or intelligent operation w/ on-board micro w/ FIFO I/O buffer and many preprogrammed modes. Or program it yourself w/ 96K bytes on-board memory. Intelligent slave or standalone operation w/ serial port. Input filters, prog. gain amp. sample-hold.

ROBOTROL CORP.
925 W. San Martin Ave., San Martin, CA 95046
(408) 683-2000

CIRCLE NO 770



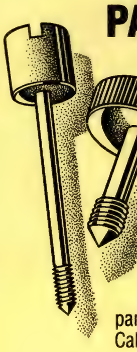
HIGH DENSITY - LOW INSERTION FORCE 70-350 POSITION BLIND MATABLE CONNECTORS

N Series rack & panel connectors are available in 70, 110, 150, 190, 230, 270, 310 and 350 position models. The use of the Hypertac® LIF (Low Insertion Force) contact provides reliable operation without space consuming, expensive caming or jacking devices.

HYPERTRONICS CORPORATION
16 BRENT DRIVE, HUDSON, MA 01749
(508) 568-0451

CIRCLE NO 771

CAPTIVE PANEL SCREWS



Globe Electronic Hardware's captive panel screws are available in stainless steel, brass or steel and can be finished to meet Mil, QQ and other standards in forty-two protective and decorative finishes. Globe, the specialists in custom screw machine parts, will also fabricate a captive panel screw to your specifications. Call, write or fax to receive Globe's comprehensive 204-page catalog on captive panel screws and our extensive line of electronic hardware.

GLOBE

GLOBE ELECTRONIC HARDWARE
32-02 57TH STREET • WOODSIDE, NY 11377
(800) 221-1505 • NEW YORK: (718) 278-2400
FAX: (718) 726-1381

CIRCLE NO 772

DESIGN IN RECORD TIME

The Fully

Integrated

CAE Design

Solution

FREE DEMO DISKS

SCHEMA II+ (schematic capture)	$495
SCHEMA-PLD (logic compiler)	$495
SCHEMA-SUSIE (simulator)	$995
SCHEMA-PCB (PCB layout)	$975

FREE 1-800 Support*30 Day Money Back Guarantee

1-800-553-9119

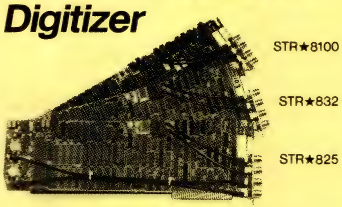
OMATION

FAX: (214) 783-9072

CIRCLE NO 773

---

100 MHz Waveform Digitizer



The fastest A/D boards for your data acquisition needs.

- transient rates of 25, 32, and 100 MHz at 8 bits
- time equivalent sampling rates up to 800 MHz
- bus interface allows 1.5 MHz throughput rates
- many trigger modes; 64K memory per channel
- XT, AT & 386 compatible; prices from $1750
- free drivers and digital oscilloscope software
- perfect for radar, ultrasound, ATE, robotics . . .

SONOTEK

8700 Morrissette Drive, Springfield, Virginia 22152
703-440-0222 ■ Telex 910-250-5257 ■ Fax 703-440-9512

CIRCLE NO 774

IBM COMPATIBLE RS232/488 3½ × 5¼" FLOPPY DATA STORAGE & TRANSFER SYSTEM

Information Transfer to/from Non IBM Compatible Systems to/from IBM & Compatibles: (Over RS-232 or 488 Interface).

- Reads & Writes MS DOS Disks
- RS-232/488 I/O
- Rugged Portable Package/battery option
- MS DOS Driver for "Plug & Run" RS-232 External Operation
- Baud Rate 110 to 38.4K Baud
- **360K/720K RAM Cartridge Option**
- Price $795 in Singles-OEM Qtys. $350.

28 other systems with storage from 100K to 42 megabytes.

ADPI

ANALOG & DIGITAL PERIPHERALS, INC.
251 South Mulberry St., Troy, Ohio 45373
P.O. Box 499 TWX 810/450-2685
513/339-2241 FAX 513/339-0070

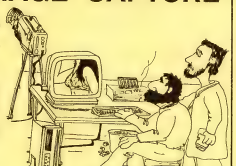
CIRCLE NO 775

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

F W COMMUNICATIONS

(508) 485-1144
FAX 508-481-7222
BBS 508-460-9203

VISION 16 IMAGE CAPTURE



LOW-COST solution to your imaging needs -- works with Crystal 3D, Lumena, Rio, Picture Power. Board and Colorscheme I software list for $1495.00 . . .

PLEASE CALL !!

BIT PAD PLUS graphics tablet -- a fine tablet at a MOUSE Price ! . . . $225.00

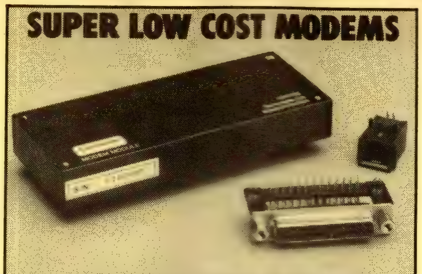
Renaissance RENDITION I PLUS advanced graphics controller. TMS-34010 powered $250.00

19-inch Ikegami monitors, perfect for image capture, at a special OEM Price !

194 Main Street Marlborough MA 01752

CIRCLE NO 776

SUPER LOW COST MODEMS



- 1200, 2400, 4800, 9600 bps
- Standard or Custom Modem Modules or PCBs
- International or Domestic
- FCC Part 68 Approved
- Quick to Market/ Guaranteed Performance

Your Source for Modem Components:

Cermetek microelectronics

Tel: 408-752-5000
Fax: 408-752-5004

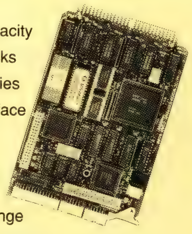
Cermetek Microelectronics, Inc.
1308 Borregas Ave. • Sunnyvale, CA 94089

CIRCLE NO 777

NEW

STD BUS COMPUTER WITH DISK SUPPORT

The 9600 integrates industrial control, operator interface, communications and disk storage functions on a single card. Also included is STD BASIC III™, a multitasking language which supports all hardware features. Hardware and software support for floppy and RAM/ROM disks in MS–DOS™ format. Ideal for complex data acquisition and control systems.



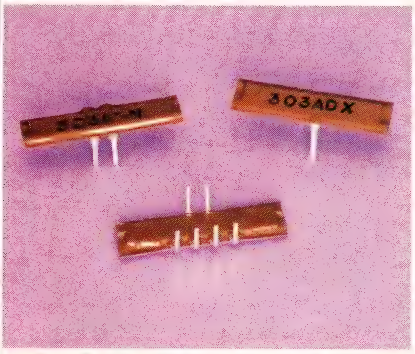
- 640K on–card memory capacity
- Supports 16 RAM/ROM disks
- Supports 3.5" & 5.25" floppies
- Opto–22 module rack interface
- Keypad & display ports
- 2 Buffered serial ports
- Real time clock support
- –20° to +65°C operating range
- CMOS/TTL compatible bus interface

Call **303–430–1500** for full line product catalog.

OCTAGON SYSTEMS CORPORATION

6510 W. 91st Avenue
Westminster, CO 80030
FAX: 303–426–8126

CIRCLE NO 778

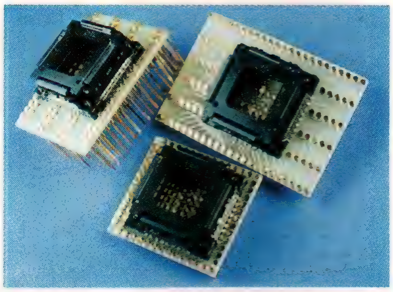


SOLVE EMI/RFI PROBLEMS

MICRO/Q 1000® capacitors with special pinout configurations give superior noise suppression, design ease. Solve special decoupling and routing problems for various microprocessors, and other devices where power and ground are not at conventional positions. **Rogers Corp.** 2400 S. Roosevelt St., Tempe, AZ. 85282. 602/967-0624

CIRCLE NO 779

PLASTIC QUAD FLATPAK



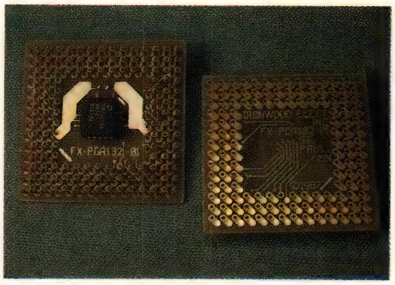
PROTOTYPING

Plastic Quad Flatpak adaptors have been added to our line of **prototyping and test adaptors**. The device is constructed with all gold plated pins (soldertail or wirewrap) and the highest quality plastic quad flat pack sockets. Parts included in this line handle 84 to 164 pin devices. Ask about our custom design services for unique solutions in packaging.

IRONWOOD ELECTRONICS
P.O. BOX 21151, ST. PAUL, MN 55121
(612) 431-7025

CIRCLE NO 780

FIX 80386

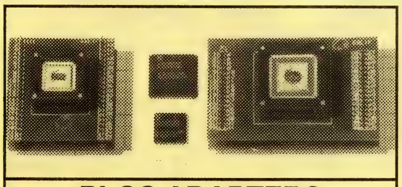


SAVES YOUR PC

The FIX-80386 solves the Errata 21 problem that is showing up on many PC's. If your **PC locks up** when running UNIX or memory extenders in MS-DOS **you will need this part**. The part is placed between the 80386 and its socket. Constructed of gold pins and sockets for highest quality. Available immediately. **ALSO ASK ABOUT OUR UNIQUE SOLUTIONS FOR PROBING PGA's, PLCC's and LCC's**.

IRONWOOD ELECTRONICS
P.O. BOX 21151, ST. PAUL, MN 55121
(612) 431-7025

CIRCLE NO 781



PLCC ADAPTERS FOR 87Cx51s

Logical Systems is proud to add PLCC support to our microcontroller socket adapters. The PLCC sockets are 3M/Textool brand Quick Lock sockets and provide positive alignment of the device with a push-in/pop-out mechanism. Devices are inserted "live-bug" and all contacts are gold.

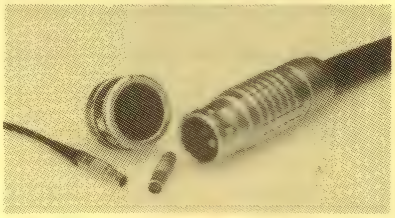
Program 87C51 PLCC on 87C51 DIP programmer OR program 8751H PLCC on 8751H DIP programmer.	**PA51-44**	**$115.00**
Program 87C451 PLCC on 87C51 DIP Programmer.	**PA451-68**	**$165.00**
Program 87C552 PLCC on 87C51 DIP programmer.	**PA552-68**	**$165.00**

CALL (315) 478-0722
FAX (315) 475-8460

Logical Systems Corporation
P.O. Box 6184, Syracuse NY 13217-6184 USA

CIRCLE NO 782

LEMO QUALITY CONNECTORS



Self-latching, circular, quick connect-disconnect connectors are available in multi or mixed contact configurations, high voltage, environmentally sealed, fiber optic, fluidic, coaxial, triaxial, thermocouple and plastic.

LEMO USA, INC.
P.O. Box 11488
Santa Rosa, CA 95406
Phone (800) 444-LEMO
FAX 707/578-0869.

CIRCLE NO 783

F W COMMUNICATIONS

(508)485-1144
FAX 508-481-7222
BBS 508-460-9203

LOW BUDGET SPECIALS

19" COLOR SUPER VGA MONITORS

LIKE NEW -- 6-MONTH WARRANTY	$800.00
USED -- 3-MONTH WARRANTY	$600.00
USED WITHOUT CASE	$300 TO$500.00

19" COLOR SONY 1280X1024 $1600.00

THESE SONY TRINITRONS HAVE A FULL 6-MONTH PARTS AND LABOR WARRANTY. LIMITED QUANTITY.

16" Ikegami 64 kHz 1280X1024 New **$899.00**

16" Panasonic 64 kHz Used **$599.00**

14" Ikegami TTL VGA chassis, New, 1-year warranty **$249.00**

19" PHILIPS 1024x800 48 kHz GRAYSCALE . . $350.00
NEW, 1-YEAR WARRANTY. MAY BE ORDERED FOR VGA AT NO EXTRA CHARGE. IN VGA MODE, WILL RUN 800X600X256 GRAYSCALE, OR 1024X768X16 GRAYSCALE ONLY.

CALL US ABOUT OUR LARGE VARIETY OF GRAPHIC CARDS!

194 Main Street Marlborough MA 01752

CIRCLE NO 784

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

OUR NEW AIR CONDITIONERS HAVE BEEN CONDENSED.

Introducing the all-new Hoffman DesignAire™2 air conditioners. From top to bottom, we've made some amazing improvements.

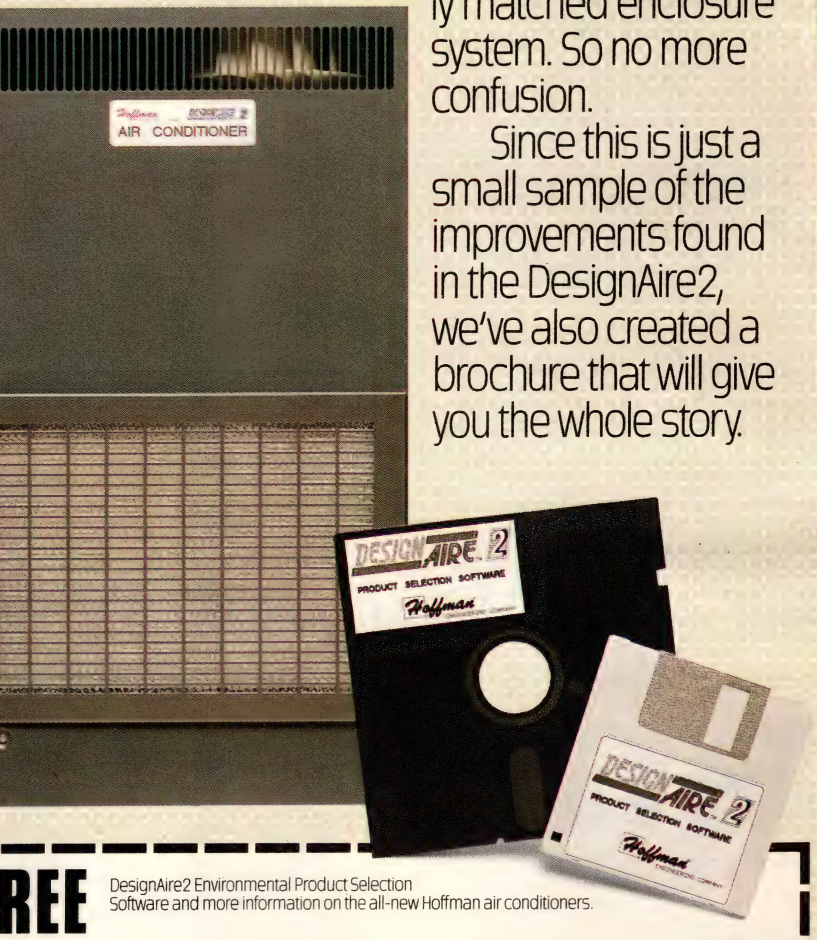
By reducing their size, they now fit perfectly on the most common sized enclosures. So no more overhang.

We've incorporated a system that evaporates the condensate outside the enclosure. So no more puddles.

Every model has a thermostat. So no more wasted energy.

We've even created a new computer program to help you quickly and accurately create a perfectly matched enclosure system. So no more confusion.

Since this is just a small sample of the improvements found in the DesignAire2, we've also created a brochure that will give you the whole story.



FREE DesignAire2 Environmental Product Selection Software and more information on the all-new Hoffman air conditioners.

Name:__________

Company:__________

Position:__________

Address:__________

City:__________ State:_____ Zip:_____

Computer: Disk Size:____ 5¼" ____ 3½"

Mail To:
Hoffman Engineering
900 Ehlen Dr.
Anoka, MN 55303
(612) 421-2240

Hoffman®
ENGINEERING COMPANY
A Pentair Company

Circle 102 for Sales Assistance

Circle 103 for Information

YES! I would like
to know even more
about Philips LCDs.

Please send me the following literature:

☐ Philips character type LCD modules.
☐ Philips LCD principles and applications.
☐ Philips LCD type range guide.
☐ Another copy of "Take an inside look at Philips LCDs".

Name ______________________________
Title ______________________________
Company ______________________________
Address ______________________________
____
Telephone no. ______________________________

Complete and post this card to the address below.

Philips Components,
Marketing Communications Department,
Building BA, 5600 MD Eindhoven,
The Netherlands.
Telex: 35000 phtc nl Fax: +31 40 724825 E
EDN031590

When it comes to LCDs,
We see things your way.

Philips Components

PHILIPS

PHILIPS

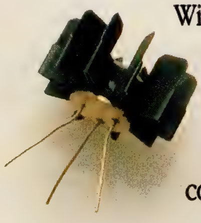
CIRCLE NO. 127

Why 90% of the Top Electronics Companies Use CAPS

for IC and Semiconductor Search and Selection

CAPS Saves Time and Money

The CAPS™ IC and Semiconductor Search and Selection System boosts your productivity and pays for itself by saving you hours of drudgery and frustration. Engineers and designers who use CAPS consistently report productivity gains between 5:1 and 10:1 over manual methods!

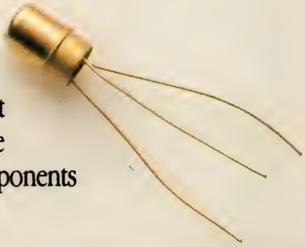


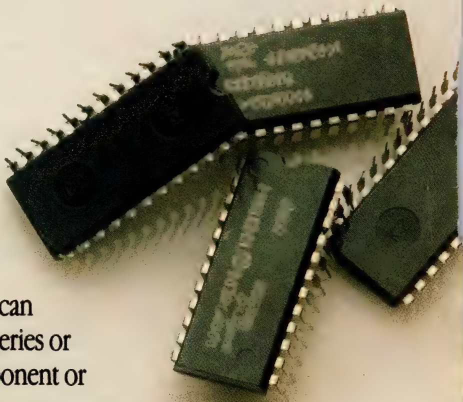
CAPS Keeps Pace with Technology

With CAPS, you get updates every month, including new component information, datasheets, and revisions to existing information. CAPS also keeps track of obsolete components for you.

CAPS Finds Facts Fast

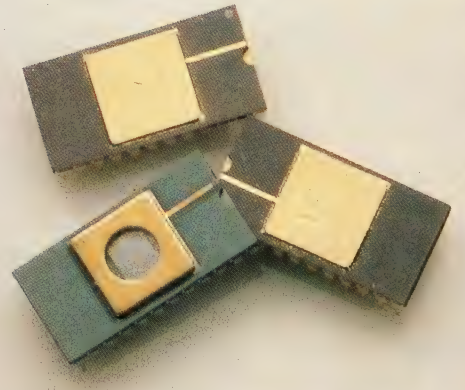
CAPS' CD-ROM database gives you instant access to complete technical data on more than 470,000 IC and semiconductor components from over 425 manufacturers worldwide.





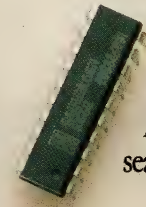
CAPS Gives You Control

CAPS puts you in charge. In seconds, you can search the database using either simple queries or special criteria to pinpoint a specific component or compare several candidates.



CAPS Runs on Existing Equipment

When you subscribe to CAPS, you get all the hardware and software you nee to add CAPS to your IBM® PC/AT™, 100%-compatible personal computer, or Sun® workstation. So you can get started right aw



Find out why so many of the top companies ranked by *Electron Business* magazine have made CAPS their IC and semiconductor search and selection tool.

CAPS Delivers the Big Picture

CAPS includes hundreds of thousands of digitally-stored images of manufacturers' datasheet pages, complete with unabridged text and graphics. CAPS even provides cost information and tells you how to contact manufacturers.

For complete information about CAPS, call or write today!

CAHNERS
CAPS
Computer Aided
Product Selection

CIRCLE NO. 113

Cahners Technical Information Service
275 Washington Street
Newton, Massachusetts 02158-1630
Telephone: 617-558-4960
Facsimile: 617-969-6949

Toll-free: 800-245-6696

CAPS is a trademark of Reed Publishing (U.S.A.) Inc.
IBM is a registered trademark and AT is a trademark of International Business Machines Corporation.
Sun is a registered trademark of Sun Microsystems, Inc.

John Holland and his robots

A love story

Jay Fraser, *Associate Editor*

Photographs by Walker Nelms

Sometimes late at night, after all the other people have left the factory, John Holland likes to sit back with a cup of coffee and watch one of his robots run. "That's one of my favorite times," he says. "When we get some new software, I love to program a robot up. I turn it on and turn off all the lights and just watch it maneuver around. It's a great feeling."

Holland, 44, is the president of Cybermotion Inc, the Roanoke, VA company that manufactures his robots. Founded in 1984, Cybermotion is already a success, and Holland's robots are being used by dozens of organizations as diverse as Rockwell International, the University of Minnesota, and NASA.

"This all started as a complete fluke," says Holland. "I'd had a very good year consulting, and I was trying to get rid of some income toward the end of the year for tax purposes. I bought some equipment, but that wasn't enough. Then I heard that the government offered tax credits for research. So I started to work on a robot."

After months of research and experimentation, Holland eventually put together a prototype. "The next thing you know I had people looking at it and saying I ought to do something with it. Then I had a partner. Then stockholders. I was sucked right in," he says, with a shrug and a smile.

Holland graduated from Virginia Polytechnic Institute and State University (Blacksburg, VA) in 1968 with a BSEE. "That's the only degree I have. I'm damn near uneducated," he says. He was always interested in robots, and he and his college friends used to talk about building them some day, but he never seriously thought he'd do it.

Holland's first job after he graduated was with Teledyne Avionics, designing analog computers for aircraft. After working there for a year he joined the army. He was a signal instructor at Fort Gordon in Georgia, then he was a communications officer with an air cavalry unit in Vietnam.

Following his discharge, Holland started a small company called Advanced Electronics to manufacture radio telemetry systems. "I began to realize that I shouldn't have been out on my own quite that early. I really wasn't learning from anybody." After one year, he sold Advanced Electronics and went to work for ITT.

Holland became the first bench engineer in ITT's Electro-optical Products Division to work with fiber optics. Although he found the work interesting at first, eventually it became routine. After more than four years at ITT, he decided to try consulting.

Pros and cons of consulting

"It seemed to me that consulting was a great way to keep moving on to new challenges," explains Holland, "but, ironically, even that became kind of boring after a while. I kept being called on to do the same sorts of things—and they were always somebody else's basic ideas. I wanted to do some things of my own."

Although Holland continued to work as a consultant for the next five years, more and more of his time and effort went into building his robot. Originally he had no plans to put it into production and sell it. "I was just doing it for the love of it," he says. When the robot was more or less completed, he affectionately dubbed it Kluge.

Kluge was assembled from parts that Holland had lying around his basement, bought second-hand, and scrounged. He ordered the World War II vintage drive motor from an army-surplus catalog. When the drive motor arrived, he discovered that it had been sealed in a bag on the day he was born. He took this to be a good omen.

Kluge was squat and boxy, 43 in. high and 27 in. wide. It consisted of a motorized base with three wheels mounted on three retractable legs and a rotating turret that contained the onboard 8-bit computer and the navigation system. It was powered by three 12V rechargeable batteries.

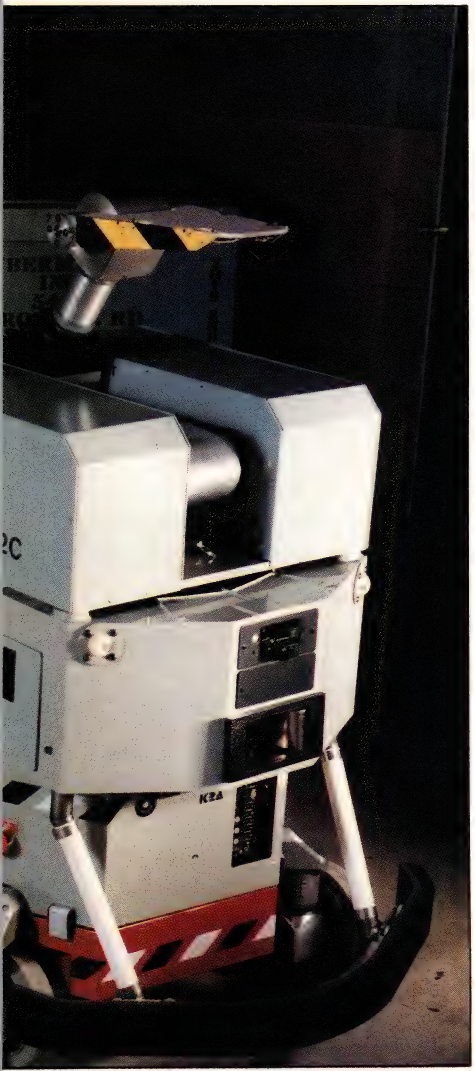
Holland built a genuine innovation into Kluge—a drive system he patented and named Synchro-drive. All three of the robot's wheels turned together. To change direction, only the wheels turned, not the base. Synchro-drive gave Kluge a turning radius of zero, and an

A Navmaster in operation. The robot can carry as much as 500 pounds.

overall movement error of less than 0.5%. The robot's turret was synchronized to turn with the wheels.

Kluge, however, had some problems. It contained three sets of motors, gear boxes, and chains—one to drive the wheels, one to steer the wheels, and one to retract and extend the legs. The chains needed 180° of engagement on each sprocket, which required the installations of many idlers. The chains also took up a lot of space, and the design gave Kluge a high center of gravity. In addition, the chains had to be periodically adjusted, and whenever they were, the wheels had to be realigned.

Holland wrote a book, *Basic Robotic Concepts*, and published a number of papers based on the research he had done. He received many inquiries about his work, including one from a small firm named Denning Mobile Robots (Woburn, MA). Denning wanted to adapt Kluge for factory guard duty. Holland licensed the design to Denning and founded his own company, Cybermotion, to develop a more advanced robot.



Holland set out to raise money for his new company. He contacted 50 venture-capital firms and was turned down by every one of them. No bank would give him a loan, either. It was the mid-1980s and "robot" had become a dirty word.

Throughout the 1970s the makers of robots had touted them as the answer to America's manufacturing woes. Robots were going to reduce costs, improve productivity, relieve workers of tedious and dangerous tasks, and make the US more competitive in world markets.

Many large manufacturing companies, such as auto makers, rushed to install robots on their assembly lines. Established high-tech companies opened robotics divisions, and new robotics companies sprang up overnight. At one time there were more than 50 suppliers of arm robots alone. "The market had overheated," says Holland succinctly. "It was crazy."

The same manufacturers, however, quickly grew disenchanted. "People began to realize that robots weren't a panacea," Holland explains. "There were places where they worked well, and places where they didn't. There were too many highly articulated robots to do the few jobs that really required them. There was a very big shaking out. The venture capitalists had gone in on a wild hare, without fully understanding the dynamics of the market. They got creamed."

Sales of robots declined sharply. In 1985 American companies spent $443 million for new industrial robots. In 1987 that figure dropped to $299 million. Large high-tech firms disbanded their robotics divisions. Small robotics companies folded. Venture capitalists turned their backs on anyone who wanted to build robots.

Undaunted, Holland hired a mechanical engineer and a designer and started to build the improved robot he had in mind. He paid his employees out of his earnings from consulting, and when that wasn't sufficient, out of his savings. Finally, he managed to raise money by selling stock to a group of small investors. When he made his proposal to them, he told them his company made "agile autonomous vehicles" to avoid using the word robot.

Making robots more mobile

One of the most persistent problems of the early mobile robots was navigation. In many factories their movements were limited to fixed pathways and guided by tracks, painted stripes, or wires embedded in the floor. It was difficult and expensive to change a pathway.

In addition, if an obstacle was blocking a pathway, the early robots had no way of moving around it. They just sat there until the obstacle was removed. They also had difficulties moving in and out of dead-end spurs. Sometimes loops or sidings had to be built for them to ensure that they could move smoothly.

Holland wanted his new robot to have an autonomous navigation system—in other words, dead reckoning. He wanted the robot to be able to travel freely between two points and maneuver around any obstacles it might encounter. He and his staff began by testing packaged infrared and sonar systems. They weren't satisfied with any of them, so they decided to try wide-angle sonar.

"We weren't enthusiastic about it," Holland remembers. "We knew all the problems of noise with sonar, and we were going to spread the beam. Where everybody else was using fairly narrow beams, such as

15°, we were going to spread it out to 70°. That meant our S/N ratio was going to be pretty bad. So we went to a number of extreme measures."

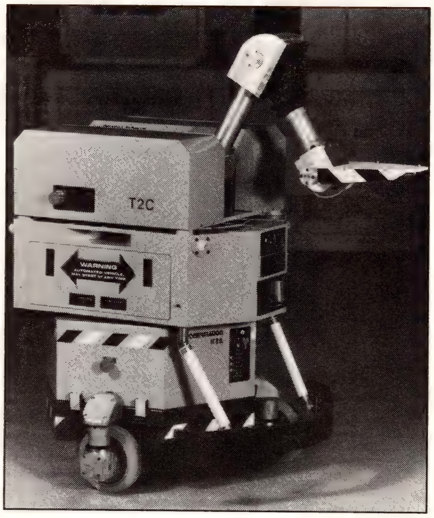
Holland and his staff put very tight filtering on their sonar. Then they digitized the echo and sent it into a dedicated processor that performed noise reduction digitally. They set it all up for a trial run to see just how bad it was.

"We found out, in fact, that it was much better than the results we had been getting with the 15° spread and no processing at all," Holland says. "It was one of those few times in electronics history when everybody was delighted and patting each other on the back. At least for a little while."

Holland mounted two sonar transducers angled toward each other on the front of his new robot. This alignment created a double-flood. If one of the transducers missed an object, the other would hit it. Some of the companies that used narrow-beam sonar had to ring their robots with as many as 24 transducers to get complete coverage. Holland only had to place two on the front, one on each side, and two on the back of his robot.

Other significant improvements in the new robot, called the Navmaster, were the elimination of the retractable legs and the chain drives. The Navmaster's three wheels were attached directly to its body, mounted on the edge of the base so they could rotate freely. They were still controlled by Synchro-drive. Holland replaced the cumbersome chain drives with a drive system of concentric shafts and bevel gears. He also put the single motor and gearbox directly on the bottom of the robot's housing, which gave it a low center of gravity.

The Navmaster is modular. It consists of a base, a subturret, and a turret, which can be changed depending on the robot's application. It can carry as much as 500 pounds and go up a 15° ramp. The Navmaster can be programmed to follow a certain path, but it will move around any obstacles in its way and the program can be changed at any time.



A Navmaster with a turret *designed for light-load handling.*

"I never thought I could make a real contribution to the field of robotics. I always figured that someone a lot smarter than I am would do that sort of thing," says Holland. "But I came to find out that you can make a contribution if you just stick with it and keep adding to it, methodically, every year."

While the Navmaster was being developed, the staff at Cybermotion grew to 11 people. "It's a small group and they work their butts off," says Holland. "They're older engineers for the most part. I guess the youngest one is in his mid-30s. We started with people who have a lot of experience so we wouldn't be making the same mistakes twice. Now we're adding younger people underneath who can learn from those people."

Holland's staff also reflects his sense of humor. They often use the robots to play tricks on each other. Holland once programmed one of his robots to stand in a corner with its lights out, pretending it was turned off. When anyone walked into the robot's sonar range it would spring forward and reach out with the arm on its turret. "Robots are so much fun to play with," says Holland.

Holland sold his first robot to General Motors in the spring of 1985. By 1988 sales had grown to approximately $500,000. They doubled in 1989, and Holland predicts they will double again this year.

At first most of the robots went to laboratories and research facilities. Now Cybermotion's biggest customers are nuclear installations. Holland expects that in the future most of his robots are going to be used for surveillance and light materials handling.

Today Holland lives on a 20-acre farm in the Blue Ridge Mountains. He owns five dogs, three horses, and a pony. He goes trail riding almost every Sunday to relax and maintain his perspective. A bachelor, he thinks of his robots as his children. "I put a lot of my life into these things," he says. "I don't think it's enough for an engineer just to get paid. I think he has to feel that he has done something worthwhile. My robots are what I'll leave to the world." **EDN**

Article Interest Quotient
(Circle One)
High 509 Medium 510 Low 511

"EDN'S MAGAZINE AND NEWS EDITIONS ADDRESS THE WORLDWIDE LINEAR IC MARKET WE'RE AFTER."

Bill Ehrsam
Vice President of Marketing
Linear Technology Corporation

"When I buy EDN's Magazine and News Editions, I'm buying a powerful worldwide circulation and the most prestigious editorial environments available. That's a combination that gets results," says Bill Ehrsam, Vice President of Marketing for Linear Technology Corporation.

Ehrsam knows industry sales for high-performance linear ICs are split between the United States, Western Europe, and the Pacific Rim. Says Ehrsam, "It's my job to choose media that mirrors the world markets."

For complete global coverage, Ehrsam places his advertising in EDN Magazine Edition and EDN News Edition. "Linear Technology Corporation is a strong supporter of EDN Magazine Edition. We rely on EDN's targeted coverage of the U.S. and Western Europe. When EDN News Edition added Pacific Rim circulation in December 1987, we added it to our media schedule."

For Bill Ehrsam, "EDN's Magazine and News Editions form the cornerstone for Linear Technology Corporation's media plan now and in the future."

Advertising in EDN Magazine and News Editions works for Linear Technology Corporation. It can work for you.

EDN

Where Advertising Works

ENGINEERS

II Morrow, Inc., a wholly owned subsidiary of United Parcel Service, is creating next generation high capacity mobile data communications networks. We have several exciting career opportunities for hands-on engineers looking for the challenge of fast-track new technology development. The following positions require a minimum of seven years experience with MSEE/MSCS preferred.

SENIOR SOFTWARE ENGINEER
NETWORK CONTROLLER

You will develop a high-performance radio network message switch. Experience is required with X.25 protocols, network management systems, and layered software architectures using the OSI model. (Position #83)

SOFTWARE TEAM LEADER
RADIO CHANNEL CONTROLLER

You will lead software engineers in developing data link software for mobile radio channels. Strong background needed in multiple access protocols, burst error correcting codes, ARQ, and multi-tasking embedded control systems. (Position #36)

RF HARDWARE TEAM LEADER
VHF LAND MOBILE

You will lead a radio design team in developing narrow-band mobile radio products. Solid experience required with low-noise, high-intercept amplifiers, fast-switching, low phase noise synthesizers, and mobile antenna systems. Strong digital background needed. (Position #41)

SYSTEMS ENGINEERING MANAGER
MOBILE DATA NETWORKS

You will lead systems engineering, integration, and testing for the mobile data network development program. Must have proven track record of taking communications network technology from system requirements through development to manufacturing release. (Position #B-7)

Located one hour south of Portland, Oregon in the spectacular Pacific Northwest, you'll enjoy a quality of life that includes a relatively low cost of living, year-round outdoor activities, and excellent schooling. We offer an exceptional compensation package and significant growth potential. Send your resume in confidence to: **II Morrow, Inc., Recruiting Department (Position name and number), P.O. Box 13549, Salem, OR 97309.** PRINCIPALS ONLY, PLEASE. An Equal Opportunity Employer.

II MORROW INC.

A UNITED PARCEL SERVICE COMPANY

CAREER OPPORTUNITIES

1990 Recruitment Editorial Calendar

Issue	Issue Date	Ad Deadline	Editorial Emphasis
Magazine Edition	Apr. 12	Mar. 22	Communications Special Issue—Communication ICs, Communication Systems, Microprocessors, Special Design Project #3
News Edition	Apr. 19	Mar. 30	ICs/Graphics Controllers/Microprocessors, Industrial Automation, Regional Profile: So. California
Magazine Edition	Apr. 26	Apr. 5	Computer Boards/Microprocessors, Power Sources, Sensors/Transducers, Special Design Project #4, Electro Show Issue
News Edition	May 3	Apr. 12	CAE/Board Layout, Education, Special Supplement: ASICs, Electro Show Issue
Magazine Edition	May 10	Apr. 19	Analogy Technology Special Issue—Analog ICs, Analog Instruments, Digital ICs/Microprocessors/ASICs, Special Design Project #5
News Edition	May 17	Apr. 27	ICs/Memory ICs, Test & Measurement, Regional Profile: Massachusetts & New Hampshire
Magazine Edition	May 24	May 3	Microprocessors, Computers & Peripherals, Semicustom ICs/ASICs, Components, Sensors & Transducers
Magazine Edition	June 7	May 17	Software, Design Tools, Microprocessor I/O Chips, μP Support Chip Directory
News Edition	June 14	May 24	Peripherals/Input Devices, Software, Special Supplement: EDA
Magazine Edition	June 21	May 31	Computer-Aided Engineering, Computers & Peripherals, Power Semiconductors, Semicustom ICs/ASICs

ANOTHER CONTINENTAL PLANTS CORP. AUCTION

Formerly The Property Of

UNISYS CORP.

On The Premises:

Bristol, **Tennessee**

Gigantic 4-Day Sale!!!

- **Very Late Model PC Board Fabricating Machinery,**
- **PCB Assembly & Test Equip.,**
- **Well Maintained Machine Tools, Plant Support Equip., More!**

Sale Dates:

Tues., Wed., Thurs. & Fri. March 27, 28, 29 & 30 9:00 A.M. Daily

Call or FAX For Free Brochure!

Mel Peters, Auctioneer,
TN Auct. Lic. No. 2229

CONTINENTAL PLANTS CORP.

301 N Canon Dr Suite 206 Beverly Hills CA 90210
(213) 276-6311 • FAX (213) 276-9499
680 N Lake Shore Dr Suite 2030 Chicago IL 60611
(312) 649-0900 • FAX (312)-649-0178

(800) 547-6311 TOLL FREE OUTSIDE CA
(213) 276-6311 (Inside.CA) • FAX (213) 276-9499

Knock, Knock.

In EDN's Magazine and News Editions, opportunity knocks all the time.

EDN Magazine Edition News Edition

At Motorola Cellular, big thinking creates small miracles.

In the rapidly growing cellular phone industry, Motorola is #1. We've beat all competitors in the race to introduce the world's smallest hand-held personal cellular phone. We call it MicroTAC. Others call it a "miracle" of big thinking . . . a major technological advance in microchips, circuit boards and the manufacturing process. And this is just one of the breakthroughs resulting from the insights and ideas of Motorola engineers, who are making a big impact on communications by making the worldwide telecommunity smaller.

If you want to shape the future of cellular technology, consider one of the following opportunities:

SOFTWARE: Real-time software development using C, UNIX*, Pascal, Ada, assembler and structured design; experience in software quality, metrics, or testing; CASE software tools (Sun, Apollo); design, programming and system debugging for telephone digital switching or data communication systems; assembler and high-level structured languages; hardware diagnostics; object oriented design, C++; software development tools such as Teamwork and Interleaf; ASN.1 (Abstract Syntax Notation); data communications protocols (CCITT #7, OSI, X.25, X.75, PAD, LAPB, LAPD, Ethernet, ISDN, CCITT V series modem, group 3 fax); modeling and simulations (GPSS, SIMSCRIPT and other simulation tools). BSEE/BSCS/BSCE or equivalent. Respond to Dept. SW.

ELECTRICAL/COMPUTER: Analog and RF circuit design, receiver or transmitter RF circuits; LCD display technology, acoustics, and 8-bit microprocessor software; infrared and fiber optics; low speed data; digital modulation; 900 Mhz RF power amplifier design with hybrid or microstrip circuitry; RF device development with device vendors; parallel and/or push-pull RF amplifier design at 900 Mhz or UHF; A/D and D/A convertors; RF propagation; passive and active filter theory; microwave antenna design; UL, EMI and RFI requirements; HP 3062 test system; HP 9000; digital hardware, microprocessor applications and interfaces; digital switching technology; firmware development methodology; PCM and digital telephony; digital signal processing; ASIC design; LAN systems, PSTN standards, ISDN standards, processor architectures, high-speed logic; 16-bit MPU design practices, programmable logic; digital modulation synchronization, adaptive signal processing, viterbi algorithm and MLSE, decision Feedback equalizer; convolutional code and linear block code, speech coding, echo cancellation, encryption; CAE techniques for digital hardware design using Mentor Graphics, etc.; data communications protocols (CCITT #7, OSI, X.25, X.75, PAD, LAPB, LAPD, Ethernet, ISDN, CCITT V series modem, group 3 fax); computer network management/administration (Apollo, Sun, Mentor Graphics, AppleTalk). BSEE/MSEE/BSCE/BSCS or equivalent. Respond to Dept. EC.

MECHANICAL: Electronic packaging; CAD, CV CADDS 4X; materials selection and geometric tolerances and dimensioning; extruded metal; injection molded plastics; life test procedures and factory introduction and support; plating materials and processes; structural analysis modeling; die casting and sheet metal stampings; thermal management. BSME/MSME or equivalent. Respond to Dept. ME.

SYSTEMS: Radio/cellular communication systems engineering; RF propagation prediction methods; PSTN traffic planning; telephone network, interconnection and telecommunication industry standards; microwave system design and equipment engineering; telephone switching systems; software programming skills. BSEE/BSCE/BSCS or equivalent. Respond to Dept. S.

For a future with a company that will value and encourage your ideas, come to Motorola Cellular where you'll find the challenges for your big thinking. We offer an excellent salary and a comprehensive benefits package. For immediate consideration, send your resume to: Supervisor, Professional Recruitment, Motorola, Inc., Cellular Group, 1501 West Shure Drive, Arlington Heights, IL 60004. Or FAX your resume to: (708) 632-5717 (our 24-hour FAX line). To access our On-Line Career Network from your PC, dial (708) 263-3857, press return twice and key in password LEGACY. We are an equal opportunity/affirmative action employer.

*Registered trademark of AT&T.

MOTOROLA
Cellular Subscriber Group

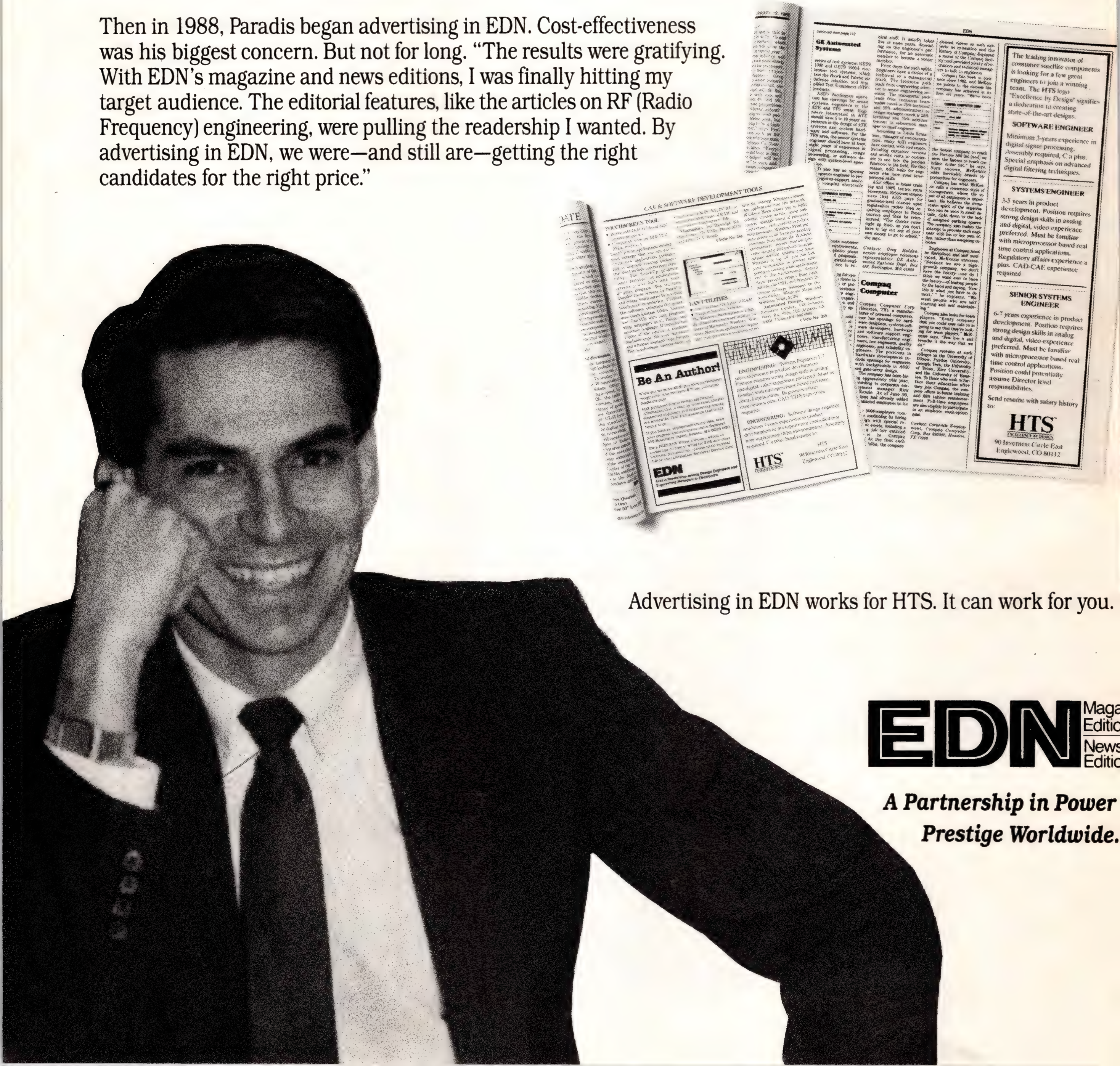
Radio Telephone Systems Group

"WITH ***EDN'S MAGAZINE*** *AND* ***NEWS EDITIONS,*** *WE GET THE RIGHT CANDIDATES FOR THE RIGHT PRICE."*

Mike Paradis
Personnel Manager
HTS

"Meeting the staffing needs of HTS is an ongoing job. Finding qualified engineers is a high priority on our corporate agenda, and of critical importance to our technical recruiting manager who is directly responsible for evaluating technical candidates," says Mike Paradis, Personnel Manager for HTS, a leading manufacturer of television satellite components and peripherals for the consumer market. "Local recruitment advertising produced shotgun results. I'd have to plow through piles of resumes, most of which weren't position related at all."

Then in 1988, Paradis began advertising in EDN. Cost-effectiveness was his biggest concern. But not for long. "The results were gratifying. With EDN's magazine and news editions, I was finally hitting my target audience. The editorial features, like the articles on RF (Radio Frequency) engineering, were pulling the readership I wanted. By advertising in EDN, we were—and still are—getting the right candidates for the right price."



The leading innovator of consumer satellite components is looking for a few great engineers to join a winning team. The HTS logo "Excellence by Design" signifies a dedication to creating state-of-the-art designs.

SOFTWARE ENGINEER

Minimum 3-years experience in digital signal processing. Assembly required, C a plus. Special emphasis on advanced digital filtering techniques.

SYSTEMS ENGINEER

3-5 years in product development. Position requires strong design skills in analog and digital, video experience preferred. Must be familiar with microprocessor based real time control applications. Regulatory affairs experience a plus. CAD-CAE experience required

SENIOR SYSTEMS ENGINEER

6-7 years experience in product development. Position requires strong design skills in analog and digital, video experience preferred. Must be familiar with microprocessor based real time control applications. Position could potentially assume Director level responsibilities.

Send resume with salary history to:

HTS
EXCELLENCE BY DESIGN
90 Inverness Circle East
Englewood, CO 80112

Advertising in EDN works for HTS. It can work for you.

EDN Maga
Editio
News
Editio

A Partnership in Power
Prestige Worldwide.

Engineers

FLORIDA OPPORTUNITIES

As the leading supplier of marketing research information on television and VCR viewing habits, we have immediate opportunities in our Engineering environment.

Our facility is located on the Sun Coast of West Central Florida where you'll encounter a beautiful climate, no state income taxes, low cost-of-living and year round outdoor recreational opportunities.

We are actively recruiting for the following positions.

LEAD SOFTWARE ENGINEER — The ideal candidate will have:

- Eight years experience in microprocessor system, operating systems
- Extensive experience in software structured design
- Knowledge of "C" and assembly language
- Project management

SR. ENGINEER — The ideal candidate will have:

- Five years directly related experience
- Experience in design of R.F. systems, particularly television, VCR, or cable box tuning
- Knowledge of "C" language processor based hardware design
- Experience in project design

Four year degree in Electrical Engineering required for the above positions.

As a leader in our industry we offer professional challenges, competitive compensation and benefits. For immediate consideration submit your resume in confidence to Human Resources Department JEDN315, NIELSEN MEDIA RESEARCH, 375 Patricia Ave., Dunedin, FL 34698.

Nielsen Media Research

DB a company of
The Dun & Bradstreet Corporation

An Equal Opportunity Employer M/F/H/V

If You're Looking For a Job, You've Come to The Right Place.

EDN CAREER
OPPORTUNITIES

EDN Magazine Edition
News Edition

Brooktree™

SEMICONDUCTOR INDUSTRY

San Diego Opportunities

Brooktree Corporation is an industry leader in the design, manufacture and marketing of electronic data conversion and signal processing integrated circuits serving the computer graphics, ATE and imaging industries. Our DACs, RAMDACs, ADCs, and related products have received wide recognition in the industry for innovation and quality. We currently have excellent career opportunities in the following areas for semi-conductor professionals experienced with CMOS/BiPolar technologies:

TEST ENGINEER

Requires experience with Trillium/LTX.

PRODUCT ENGINEER

Requires industry experience with development and/or sustaining in a high-volume product engineering environment. Yield analysis experience preferred.

QA ENGINEER

Must be experienced in commercial/military semiconductor compliance procedures.

DIGITAL DESIGN ENGINEER

Needed for image signal processing. Must have experience in standard cell design.

CAD ENGINEER

Must have experience in industry available standard cell tools.

APPLICATIONS ENGINEER

Must have design/application experience in ATE, imaging and/or graphic system integration.

RELIABILITY ENGINEER

Must have experience in reliability analysis/testing of ICs.

FAILURE ANALYSIS ENGINEER

Requires knowledge of circuit theory, device physics and all aspects of failure analysis.

SECTION MANAGER, QA

Must have supervisory/management experience with a strong knowledge of QA systems and statistics.

The above positions require a BSEE or related degree (MSEE preferred) and three plus years' directly related experience.

Brooktree offers a highly competitive compensation and benefits package, including stock participation, and an Employee Bonus Program. More importantly, we provide a work environment where creativity, individual achievement and teamwork are encouraged and rewarded.

If you possess the qualifications for any of these positions and want to join a winning team, please submit your resume with salary history to: **BROOKTREE CORPORATION, Professional Staffing, 9950 Barnes Canyon Road, San Diego, CA 92121-2790.** We are an Equal Opportunity Employer. Principals only.

EDN Databank

Professional Profile

Announcing a new placement service for professional engineers!

To help you advance your career. Placement Services, Ltd. has formed the EDN Databank. What is the Databank? It is a computerized system of matching qualified candidates with positions that meet the applicant's professional needs and desires. What are the advantages of this new service?

- **It's absolutely free. There are no fees or charges.**
- **The computer never forgets. When your type of job comes up, it remembers you're qualified.**
- **Service is nationwide. You'll be considered for openings across the U.S. by PSL and it's affiliated offices.**
- **Your identity is protected. Your resume is carefully screened to be sure it will not be sent to your company or parent organization.**
- **Your background and career objectives will periodically be reviewed with you by a PSL professional placement person.**

We hope you're happy in your current position. At the same time, chances are there is an ideal job you'd prefer if you knew about it.

That's why it makes sense for you to register with the EDN Databank. To do so, just mail the completed form below, along with a copy of your resume, to: Placement Services, Ltd., Inc.

IDENTITY

Name ____________________

Home Address: ____________________

City __________ State: __________ Zip: __________

Home Phone (include area code): ____________________

PRESENT OR MOST RECENT EMPLOYER

Parent Company ____________________

Your division or subsidiary: ____________________

Location (City, State) ____________________

Business Phone if O.K. to use: ____________________

EDUCATION

Degrees (List)	Major Field	GPA	Year Degree Earned	College or University

POSITION DESIRED

____

EXPERIENCE

Present or Most Recent Position From: __________ To: __________ Title: __________

Duties and Accomplishments: __________ Industry of Current Employer: __________

Reason for Change: ____________________

PREVIOUS POSITION:

Job Title: ____________________

Employer: __________ From: __________ To: __________ City: __________ State: __________

Division: __________ Type of Industry: __________ Salary: __________

Duties and Accomplishments: ____________________

COMPENSATION/PERSONAL INFORMATION

Years Experience	Base Salary	Commission	Bonus	Total Compensation	Asking Compensation	Min. Compensation

Date Available	I Will Travel ☐ Light ☐ Moderate ☐ Heavy	☐ I own my home. How long? __________ I rent my home/apt. ☐
☐ Employed ☐ Self-Employed ☐ Unemployed	☐ Married ☐ Single	Height __________ Weight __________
Level of Security Clearance	☐ U.S. Citizen ☐ Non-U.S. Citizen	My identity may be released to: ☐ Any employer ☐ All but present employer

☐ WILL RELOCATE ☐ WILL NOT RELOCATE ☐ OTHER ____________________

EDN Databank

A DIVISION OF PLACEMENT SERVICES LTD., INC.

265 S. Main Street, Akron, OH 44308 216/762-0279

BUSINESS/CORPORATE STAFF

Peter D Coley
VP/Publisher
Newton, MA 02158
(617) 964-3030; Telex 940573
Ora Dunbar, Assistant/Sales Coordinator

Mark J Holdreith
Associate Publisher/
Advertising Sales Director
Newton, MA 02158
(617) 964-3030
Heather McElkenny, Assistant

Deborah Virtue
Business Director
Newton, MA 02158
(617) 964-3030

NEW ENGLAND
Chris Platt, Regional Manager
Clint Baker, Regional Manager
199 Wells Ave
Newton, MA 02159
(617) 964-3730

STAMFORD 06904
George Isbell, Regional Manager
8 Stamford Forum, Box 10277
(203) 328-2580

NEW YORK, NY 10011
Daniel J Rowland, Regional Manager
249 West 17th St
(212) 463-6419

PHILADELPHIA AREA
Steve Farkas, Regional Manager
487 Devon Park Dr, Suite 206
Wayne, PA 19087
(215) 293-1212

CHICAGO AREA
Greg Anastos, Regional Manager
Jack Johnson, Regional Manager
Holli Gronset, Telemarketing
Cahners Plaza
1350 E Touhy Ave, Box 5080
Des Plaines, IL 60017
(708) 635-8800

DENVER 80206
John Huff, Regional Manager
44 Cook St
(303) 388-4511

DALLAS 75243
Don Ward, Regional Manager
9330 LBJ Freeway, Suite 1060
(214) 644-3683

SAN JOSE 95128
Walt Patstone, Regional Manager
Bill Klanke, Regional Manager
Philip J Branon, Regional Manager
James W Graham, Regional Manager
3031 Tisch Way, Suite 100
(408) 243-8838

LOS ANGELES 90064
Charles J Stillman, Jr
Regional Manager
12233 W Olympic Blvd
(213) 826-5818

ORANGE COUNTY/SAN DIEGO 92715
Jim McErlean, Regional Manager
18818 Teller Ave, Suite 170
Irvine, CA
(714) 851-9422

PORTLAND, OREGON 97221
Pat Dakin, Regional Manager
Walt Patstone, Regional Manager
1750 SW Skyline Blvd, Box 6
(503) 297-3382

UNITED KINGDOM/BENELUX
Jan Dawson, Regional Manager
27 Paul St
London EC2A 4JU UK
44 01-628 7030
Telex: 914911; FAX: 01-628 5984

SCANDINAVIA
Stuart Smith
27 Paul St
London EC2A 4JU UK
01-628 7030
Telex: 914911; FAX: 01-628 5984

FRANCE/ITALY/SPAIN
Alasdair Melville
c/o Editions J C B
Bureau 443
14 Boulevard Poissonniere
75009 Paris France
(331) 45 23 22 04
Fax: (331) 42 46 84 43
Telex: 648245

WEST GERMANY
Wolfgang Richter
Sudring 53
7240 Horb/Neckar, West Germany
49-7451-7828; Telex: 765450

AUSTRIA/SWITZERLAND/BAVARIAN GERMANY
Hans Haller
Preysingstrasse 30
8000 Munich 80 West Germany
(49) 89 48 8054
Fax: (49) 89 47 080 73; Telex: 523297

ISRAEL
Asa Talbar
Talbar Media
5 Bnei Brit St
Jerusalem 95146 Israel
0222 8 083; Fax: 9722-247-403

FAR EAST
Jack Kompan, Asian Director of Marketing
18818 Teller Ave, Suite 170
Irvine, CA 92715
(714) 851-9422; Telex: 183653

HONG KONG
John Byrne & Associates Ltd
1613 Hutchison House
10 HGarcourt Road
Central Hong Kong
Tel: 5-265474
Telex: 61708 WEDIN HX
Fax: 5-8106781

JAPAN
Kaoru Hara
Dynaco International Inc
Suite 1003, Sun-Palace Shinjuku
8-12-1 Nishishinjuku, Shinjuku-ku
Tokyo 160, Japan
Tel: (03) 366-8301
Telex: J2322609 DYNACO

KOREA
Seo Jeong-Gwon
Doo Bee International Ltd
Center Bldg
1-11, Jeong-dong
Choong-ku, Seoul Korea
02-776-2096
Fax: 02-755-9860
Telex: K27117 DOOBEES

SINGAPORE/MALAYSIA/INDONESIA/THAILAND/ THE PHILIPPINES/AUSTRALIA/NEW ZEALAND
Asia Pacific Media House PTE Ltd
Peter Cheong
100 Beach Rd
#24-03 Shaw Tower
Singapore 0718
Tel: 2915354; Telex: RS 50026 MESPLY

TAIWAN
Acteam International Marketing Corp
6F, No 43, Lane 13
Kwang Fu South Rd
Mailing Box 18-91
Taipei, Taiwan ROC
760-6209 or 760-6210
Telex: 29809; FAX: (02) 7604784

PRODUCT MART
Joanne Dorian, Manager
249 West 17th St
New York, NY 10011
(212) 463-6415

INFO CARDS
Donna Pono
Newton, MA 02158
(617) 558-4282

CAREER OPPORTUNITIES/CAREER NEWS
Roberta Renard, National Sales Manager
103 Eisenhower Parkway
Roseland, NJ 07068; (201) 228-8602

Janet O Penn, Eastern Sales Manager
103 Eisenhower Parkway
Roseland, NJ 07068; (201) 228-8610

Paula Compton, Western Sales Manager
18818 Teller Ave, Suite 170
Irvine, CA 92715; (714) 851-9422

Diane Philipbar, Sales Assistant
103 Eisenhower Parkway
Roseland, NJ 07068; (201) 228-8608

Wendy A Casella, Nan E Coulter, Aileen B Turner,
Advertising/Contracts Coordinators; (617) 964-3030

William Platt, Senior Vice President, Reed Publishing USA

Cahners Magazine Division
Terry McDermott, President, Cahners Publishing Co
Frank Sibley, Senior Vice President/General Manager,
Boston Division
Tom Dellamaria, VP/Production & Manufacturing

Circulation: Denver, CO: (303) 388-4511
Eric Schmierer, Group Manager

Reprints of EDN articles are available on a custom printing basis at reasonable prices in quantities of 500 or more. For an exact quote, contact Joanne R Westphal, Cahners Reprint Service, Cahners Plaza, 1350 E Touhy Ave, Box 5080, Des Plaines, IL 60018. Phone (708) 635-8800.

EDN's CHARTER

EDN is written for professionals in the worldwide electronics industry who design, or manage the design of, products ranging from circuits to systems.

EDN provides accurate, detailed, and useful information about new technologies, products, design techniques, and careers.

EDN covers new and developing technologies to inform its readers of practical design matters that will be of concern to them at once or in the near future.

EDN covers new products
- that are immediately or imminently available for purchase
- that have technical data specified in enough detail to permit practical application
- for which accurate price information is available.

EDN's Magazine Edition also provides specific "how to" design information that its readers can use immediately. From time to time, EDN's technical editors undertake special "hands on" engineering projects that demonstrate EDN's commitment to readers' needs for useful design information.

EDN's News Edition also provides comprehensive analysis and news of technology, products, careers, and distribution.

EDN
275 Washington St
Newton, MA 02158
(617) 964-3030

EDN's INTERNATIONAL ADVERTISERS INDEX

Aavid Engineering . . . 182
ACCEL Technologies Inc . . . 215
Adams-Macdonald Corp . . . 215
ADPI . . . 216
Advanced Micro Systems Inc . . . 211
Aerospace Optics . . . 107
AMD . . . 12-13
Amerace Corp . . . 34
American Automation . . . 178
AMP . . . 14-15
Analog Devices Inc . . . 114-115
Analogic Corp . . . 68
Annulus Technical Ind Inc . . . 214
Antex Electronics . . . 192
Apex Microtechnology Corp . . . 245
ARI/American Reliance Inc . . . 213
Astec . . . 140
Avantek . . . 188
B&C Microsystems . . . 213, 215
Bitwise Designs Inc . . . 212
BP Microsystems . . . 214
Burr-Brown Corp . . . 123
CAD Software Inc . . . 111
Cahners CAPS . . . 232
Cal-Av . . . 211
Capital Equipment Corp . . . 30
Ceibo Ltd . . . 215
Centronic . . . 213
Cermetek . . . 217
C&K Components Inc . . . 28
Comlinear Corp . . . 208-209
Compact Software . . . 93
Component Mfg Service Inc . . . 166
Condor . . . 37
Connor Peripherals . . . 8
Cubit/Proteus Industries Inc . . . 110
Cybernetic Micro
  Systems . . . 214, 216
Dale Electronics Inc . . . 25, 192
Dallas Robotics . . . 213
Data I/O Corp . . . C4
Datakey . . . 191, 193, 195
Data Translation Inc . . . 57
Delevan Div . . . 200
Dialight Corp, A Cambridge Electronic
  Industries Co . . . 29
Digital Equipment
  Corp* . . . 62-65, 112-113
Diversified Technology . . . 87
DSP Development Corp . . . 167
Eastman Chemical . . . 205
ECM . . . 210
Elmec Technology
  of America Inc . . . 212
Emulation Technology Inc . . . 40, 215
Foxboro Co . . . 40
Fujitsu Component* . . . 67
Fujitsu Limited** . . . 10-11
F&W Communications . . . 217
General Electric
  Plastics . . . 199, 200, 201, 203
General Silicones . . . 212
Gespac Inc . . . 41
Global Specialties Corp . . . 211
Globe Electronic Hardware Inc . . . 216
Globtek Inc . . . 213
Hewlett-Packard Co . . . 18-19, 20
Hitachi America Ltd* . . . 82, 237
Hoffman Engineering . . . 218
Hypertronics Corp . . . 216
Illinois Capacitor . . . 212
Integrated Device
  Technology Inc . . . 54
Integrated Power Design . . . 190
Integrated Silicon Systems . . . 139
International Rectifier . . . C3
Interphase Corp . . . 202
Intusoft . . . 214
IOtech Inc . . . 213
Ironwood Electronics Inc . . . 217
ITT Cannon . . . 23
Jameco Electronics . . . 214
John Fluke Manufacturing
  Co Inc* . . . 10-11, 211
Kepco Inc . . . 156-157
Kyocera . . . 6
L-Com Inc . . . 216
Lemo USA Inc . . . 217
Linear Technology Corp . . . 185-186
Logical Devices Inc . . . 175
Logical Systems Corp . . . 217
Magnetek/Triad . . . 214
Marshall . . . 66
MathSoft Inc . . . 200
Matrix Systems . . . 168
Maxim Integrated Products . . . 35-36
MCSI . . . 212
Meade Instruments* . . . 52
Mechanical Products . . . 212
MetaLink Corp . . . 215
Micro/Sys . . . 207
Mini-Circuits Laboratories . . . 26, 27,
  44-45, 183, 246
Motorola Microelectronics . . . C2
NAS Electronics . . . 187
National Instruments . . . 2
National Semiconductor
  Corp . . . 127-129
National Standards Association . . . 42
Nohau Corp . . . 211
Octagon Systems . . . 217
Omation Inc . . . 216
Ontario Ministry of Industry Trade &
  Technology . . . 158
OrCAD Systems Corp . . . 105
Orion Instruments . . . 43
Panelgraphic Corp . . . 213
Performance Semiconductor
  Corp . . . 31
Phillips Components
  Inc . . . 50-51, 219-231
Pico . . . 62, 198
Plessey Semiconductor . . . 32-33
Precision Interconnect . . . 165
Precision Monolithics Inc . . . 48
Premo Precision Electronics . . . 211
Qualidyne Systems Inc . . . 168A-D
RAF Electronic Hardware Inc . . . 182
RLM Research . . . 214
Robotrol . . . 216
Rockwell International . . . 46-47
Rogers Corp . . . 212, 215, 217
Rohm Corp . . . 206
Samsung Semiconductor* . . . 69-80
Samtec Inc . . . 120
Siemens AG** . . . 61, 63, 65, 67, 82
Siemens Corp* . . . 155
Sierra Systems . . . 141
Signum Systems . . . 214
Silicon General . . . 91
Siliconix Inc . . . 4
Sipex Corp* . . . 61
Sonotek . . . 216
Spectrum Software . . . 197
Tatum Labs . . . 213
T-Cubed Systems Inc . . . 215
TDK Corp of America . . . 84
TEAC Corp** . . . 52
Tekra . . . 107
Tektronix Inc . . . 89
Teledyne Relays . . . 96
Teltone Corp . . . 215
Tempustek . . . 213
Teradyne Inc . . . 16-17
Texas Instruments
  Inc . . . 97-100, 116-119
Thomas and Betts Corp . . . 81
Tokin Corp . . . 194
Toshiba America Inc . . . 94-95
TTE Inc . . . 166
Vectron Laboratories Inc . . . 207
Vicor . . . 38-39
Vitelic . . . 92
Wavetek . . . 3
Wintek Corp . . . 212
Xeltek . . . 214
Yamaha LSI . . . 173
Ziatech Corp . . . 1
Zilog Inc . . . 125
Zitel . . . 176-177
Z-World . . . 216

Immediate SatisFAXtion Advertisers
(See card at front of magazine)
Force Computer
Ready Systems
Siemens
Vicor

Recruitment Advertising 238-242

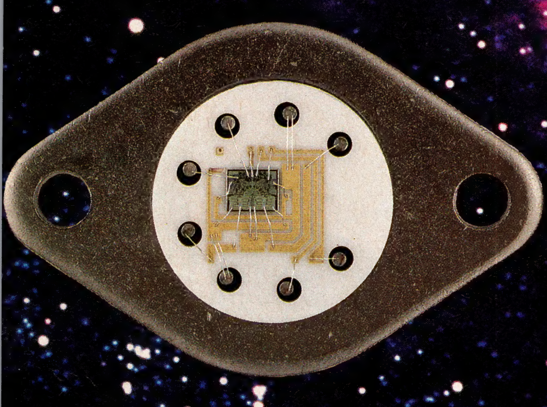
*Advertiser in US edition
**Advertiser in International edition

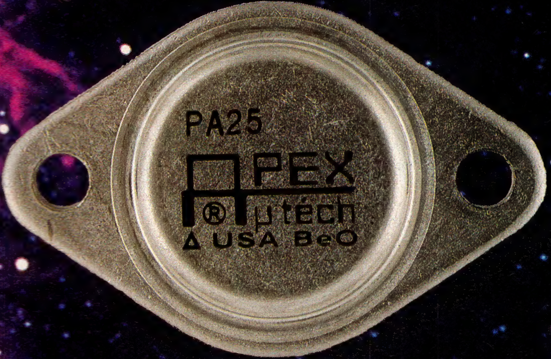
This index is provided as an additional service. The publisher does not assume any liability for errors or omissions.

A DUO OF DUALS
POWER DUAL OPERATIONAL AMPLIFIERS

- Low Cost - 21.^{50} in 100's
- High Output Current - 3 Amps
- Saturation Voltage <3.5 Volts
- Thermal Shutdown
- Ideal for Single Supply Operation

PA21





PA25A

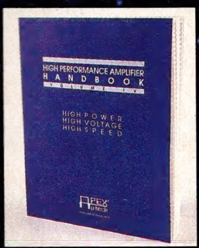
- Pin compatible with OPA2541
- Provides a high-performance second source when supply voltages are less than 40 volts

POWER AND
PERFORMANCE
GIVE YOU THE EDGE

APEX®
μtech
DEDICATED TO EXCELLENCE

To Place An Order Call
602•742•8601

For Applications Assistance Call
1•800•421•1865



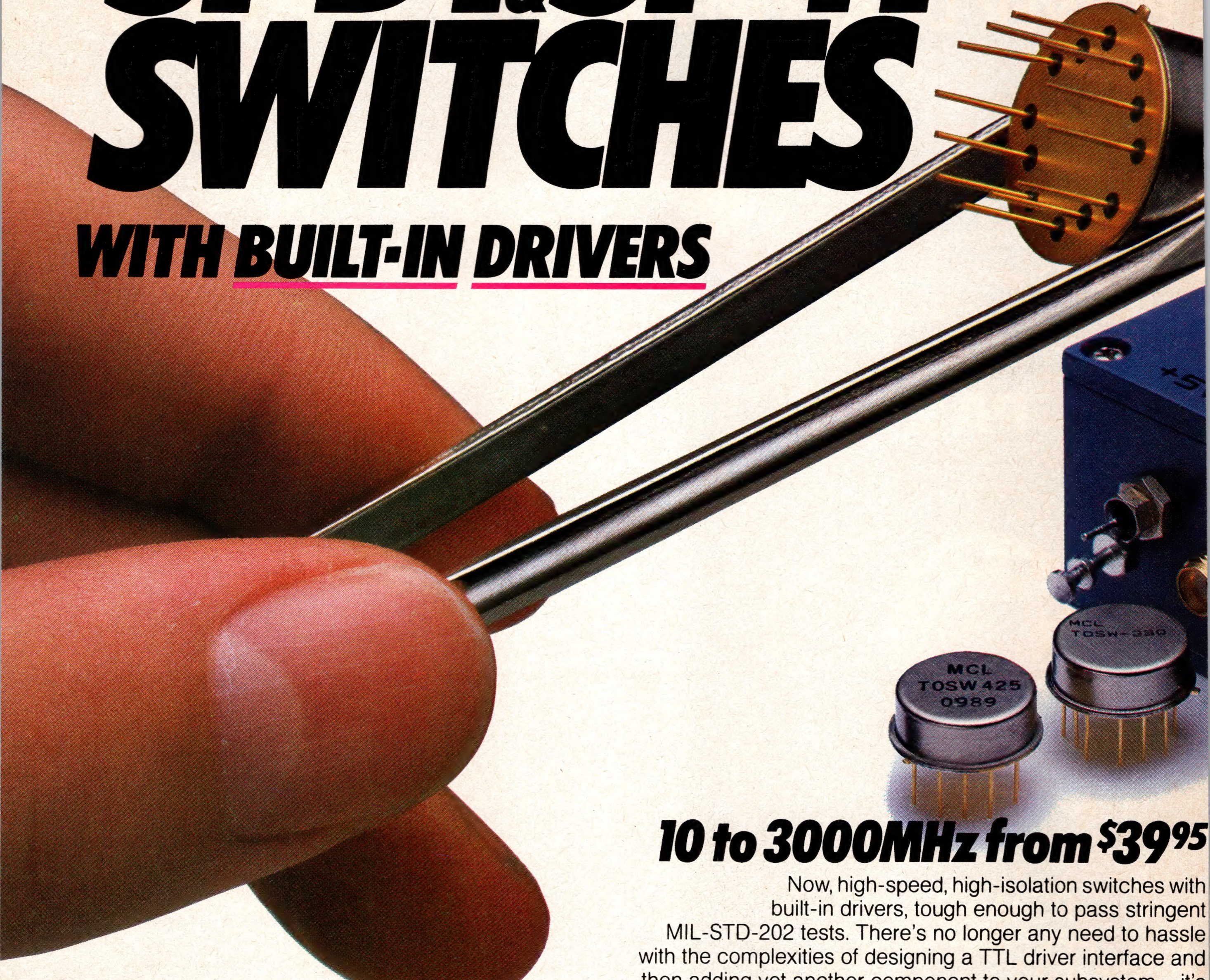
To receive your copy of our High Performance Amplifier Handbook please call
1•800•448•1025

APEX MICROTECHNOLOGY CORPORATION
5980 North Shannon Road, Tucson, AZ 85741

CIRCLE NO. 114

SPDT & SP4T SWITCHES

WITH BUILT-IN DRIVERS



10 to 3000MHz from $\$39^{95}$

Now, high-speed, high-isolation switches with built-in drivers, tough enough to pass stringent MIL-STD-202 tests. There's no longer any need to hassle with the complexities of designing a TTL driver interface and then adding yet another component to your subsystem…it's already included in a rugged, low-cost, compact assembly.

Available in the popular hermetically-sealed TO-8 package or a small EMI-shielded metal connectorized case, these tiny PIN-diode reflective switches, complete with driver, can operate over a 10 to 3000MHz span with a fast 2μsec switching speed.

Despite their small size, these units offer isolation as high as 40dB(typ), insertion loss of only 1.1dB(typ), and a 1dB compression point of +27dBm over most of the frequency range. All models are TTL-compatible and operate from a dc supply voltage of 4.5 to 5.5 V with 1.8mA quiescent current.

Switch to Mini-Circuits for highest quality innovative products…and leave the driving to us.

SPECIFICATIONS

	TOSW-230 ZSDR-230		TOSW-425 ZSDR-425	
Freq. Range(MHz)	10-3000		10-2500	
Insert. Loss (dB)	typ.	max.	typ.	max.
10-100MHz	1.3	1.9	1.3	1.7
100-1500MHz	1.1	1.9	1.1	1.7
1500-3000MHz	1.8	2.7	1.8	2.5
Isolation(dB)	typ.	min.	typ.	min.
10-100MHz	60	40	60	40
100-1500MHz	40	28	40	30
1500-3000MHz	35	22	35	22
1dB Compression(dBm)	typ.	min.	typ.	min.
10-100MHz	17	6	17	6
100-1500MHz	27	19	27	19
1500-3000MHz	30	28	30	28
VSWR(ON)	typ.	max.	typ.	max.
	1.3	1.6	1.3	1.6
Switching Time (μsec)	typ.	max.	typ.	max.
(from 50% TTL to 90% RF)	2.0	4.0	2.0	4.0
Oper. Temp.(°C)	-55 to +100		-55 to +100	
Stor. Temp.(°C)	-55 to +100		-55 to +100	
Price (10-24)	**$39.95**		**$59.95**	
(1-9)	$89.95		$109.95	

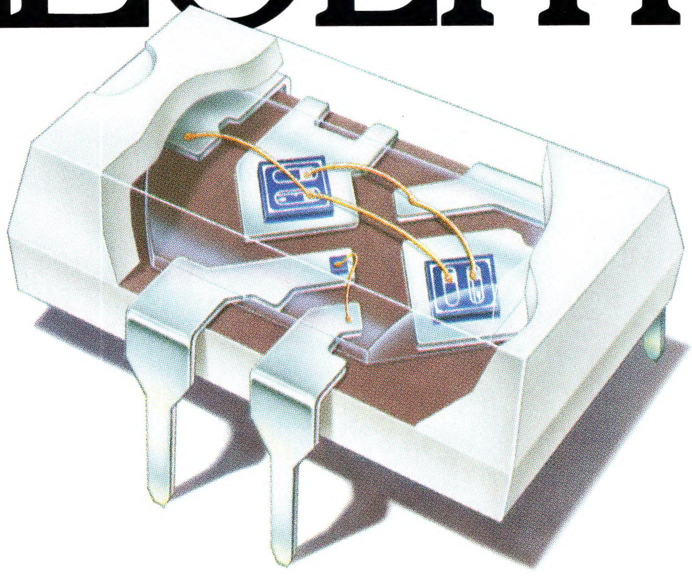
finding new ways…
setting higher standards

Mini-Circuits
A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156
WE ACCEPT AMERICAN EXPRESS

CIRCLE NO. 125

F126 REV.A

MONOLITHIC VERSUS PALEOLITHIC.



The first power IC solid state relays.

From International Rectifier come Microelectronic Relays with the most important advance in photo-isolated SSRs since we invented them: smart power IC technology.

The ChipSwitch family switches AC power lines up to 3 amps and combines on-chip zero-crossing, photo-sensing, and thyristor circuitry. With incredible surge current and dv/dt handling capability, ChipSwitch can control loads of any power factor.

Or if your application calls for general signal level switching, there's IR's line of PhotoVoltaic Relays. Their secret is the BOSFET® smart power IC, the ultimate output switch. It's based on IR's HEXFET,® the ultimate MOSFET technology.

PVRs can control analog signals from microvolts to hundreds of volts, from nanoamps to hundreds of milliamps, from DC to hundreds of kilohertz. And their size advantage saves you board space, while their bounce-free operation saves you headaches.

In other words, we're not just talking about new relays. We're talking about a new age. Call 1-800-245-5549 for *The Microelectronic Relay Designer's Manual.*

IOR INTERNATIONAL RECTIFIER

WORLD HEADQUARTERS: 233 KANSAS ST., EL SEGUNDO, CA 90245, U.S.A. (213) 772-2000. TWX 910 348-6291, TELEX 472-0403. EUROPEAN HEADQUARTERS: HURST GREEN, OXTED. SURREY RH8 9BB, ENGLAND TELEPHONE (0883) 713215, TELEX 95219

THE UNISITE PROGRAMMER: BECAUSE STATE-OF-THE-ART IS A STATE OF CHANGE.

PROGRAMMING TECHNOLOGY THAT SUPPORTS ADVANCED DESIGNS—TODAY AND TOMORROW. The UniSite™'s universal programming technology is the fastest and easiest way to keep up with new devices and packages. Its software-configured pin driver system provides a single site for programming any DIP device up to 48 pins, including PLDs, PROMs, IFLs, FPLAs, EPROMs, EEPROMs and microcontrollers.

The optional ChipSite™ module supports logic, memory and micro-controllers in the most popular surface-mount packages—PLCCs, LCCs and SOICs. Or add SetSite™ to gang program up to eight 40-pin EPROMs, or set program a single file into multiple EPROMs.

INSTANT ACCESS TO NEW DEVICES. The UniSite's device algorithms and system software are stored on 3½″ micro diskettes, which are updated several times per year. To update the UniSite, simply load new master diskettes.

FAST, EASY PROGRAMMING. Menu-driven operation with step-by-step prompts makes programming simple. For added convenience, you can operate the UniSite from an ASCII terminal or from a PC using the provided terminal emulator. On-screen help messages are available throughout operation.

To speed parts selection, the UniSite provides a built-in list of devices by manufacturer name and number. You can also save your most frequently used programming parameters and jobs for instant recall.

DESIGN FREEDOM FOR TOMORROW. When leading-edge designers need to use the latest devices, they need the programming freedom only the UniSite provides. Call Data I/O® today, and ask about the UniSite. Because state-of-the-art never stops changing.

1-800-247-5700

Data I/O Corporation 10525 Willows Road N.E., P.O. Box 97046, Redmond, WA 98073-9746, U.S.A. (206) 867-6899/Telex 15-2167
Data I/O Canada 6725 Airport Road, Suite 302, Mississauga, Ontario L4V 1V2 (416) 678-0761
Data I/O Europe World Trade Center, Strawinskylaan 633, 1077 XX Amsterdam, The Netherlands +31 (0)20-6622866/Telex 16616 DATIO NL
Data I/O Japan Sumitomoseimei Higashishinbashi Bldg., 8F, 2-1-7, Higashi-Shinbashi, Minato-Ku, Tokyo 105, Japan
(03) 432-6991/Telex 2522685 DATAIO J

DATA I/O
Corporation

©1989 Data I/O Corporation

CIRCLE NO. 74